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A READING FROM VESALIUS
AND
THE PHYSIOLOGY OF VESALIUS

A READING FROM ANDREAE VESALII, DE CORPORIS HUMANI FABRICA LIBER VII DE VIVORUM SECTIONE NONNULLA CAPUT XIX*

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T has always seemed to the writer when inspecting and studying the epoch-making folio of Vesalius, *Andreae Vesalii, De corporis humani fabrica, Libri septem,* that everyone limits one's attention to the illustrations, and that no one ever attempts to read or translate the text. This results from difficulties of the modern physician in handling the Latin language, and from the remarkable character of the drawings of the dissections, and their skillful and artistic reproduction by Jan Stephan van Calcar, the artist, by engraving on wood.

The following translation is an attempt to understand just what Vesalius knew of physiology, and to determine if possible why he did not discover the circulation of the blood. The last chapter of the seventh book of the Vesalian Treatise has been selected. The text used is that of the second edition which was published twelve years after the first, also at Basel, and by the same printer, Joannes Oporinus. This second edition was rewritten in part and contains some new material which often consists of the insertion of only a single or a few words. The larger size of the volume is due not so much to the rewriting of the text as to the fact that it was printed in a larger type than that used in the first edition.

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The second edition is a book of 824 pages of 49 lines each, while the first consists of 663 pages of 57 lines each. This final chapter of Book Seven consists of 336 lines divided into 7 pages while in the first edition it is made up of only 5 pages containing 280 lines. It is the final chapter in the last of the seven books of the work of Vesalius, and treats exclusively of vivisection.

I take pleasure at this time in acknowledging the help in the translation of this chapter from Vesalius of William Ward Foshay, studiosus Harvardiensis, and of Frank Hinchley Platt secundus, studiosus Yalensis, fellow anglers with me in the headwaters of the Androscoggin; and in its final revision, of Miss Gertrude Annan, Miss Helen Field and Miss Eleanor Sheldon, of the Librarian's staff at the New York Academy of Medicine.

In deciding on a format for the version of this chapter in English, the periods beginning with capital letters have been treated as paragraphs, and the marginal headings of the original are introduced as subtitles for presentation of the separate subjects.

NOTE:—The republication of this paper so soon after its appearance in the Proceedings of the Charaka Club seems advisable to the author, in order that a basic error may be corrected. It is believed that sufficient credit was not given to Caesalpinus in the original publication. This was due to the impossibility to consult in New York City the original book of Caesalpinus of 1583, "De Plantis." A corrected statement of the claims of Andreas Caesalpinus as a discoverer, as now understood by the author, is presented in this version.

ANDREAE VESALII DE CORPORIS HUMANI FABRICA LIBER VII DE VIVORUM SECTIONE NONNULLA—CAPUT XIX

Quid mortuorum sectione & quid vivorum discatur.

ERINDE sane ac mortuorum sectio cujusque partis numerum, situm, figuram, substantiae proprietatem & compositionem accuratissime docet: ita quoque vivi animantis sectio interim functionem ipsam manifesto ostendit, interim ad hujus inventionem ratiocinationes percommode exhibet. quare etiam merito in mortuis animantibus primum studiosi veniunt exercitandi, ut postmodum actionem usumque partium inquisituri, prompte vivum animal aggrediantur. Caeterum quum corporis permultae sint particulae, differentibus actionibus usibusque dicatae: multiplices quoque vivorum sectiones esse, neminem decet ambigere. In ossibus quippe, ut seriatim singula pertractemus, a vivorum Anatome petimus, num corporis haec optimum fulcrum ac firmamentum sint, numque omnia his adnascantur, adstabilianturque quum enim vivi animantis os aliquod ruptum cernimus, universum membrum fracturae sub-

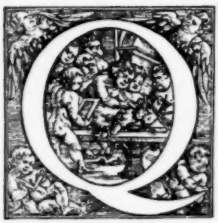
Ossium ac Cartilaginum usus in vivo animanti qui videndus.

THE SEVENTH BOOK CONCERNING THE STRUCTURE OF THE HUMAN BODY

ANDREAS VESALIUS

CHAPTER XIX CONCERNING SOME DISSECTION OF THE LIVING

What May Be Learned by Dissection of the Dead and What of the Living



UITE as the dissection of the dead teaches well the number, position and shape of each part, and most accurately the nature and composition of its material substance, thus also the dissection of a living animal clearly demonstrates at one time the function itself, at another time it shows very conveniently the reasons for its existence. Whereby also even though students deservedly first come to be skilled in the study of dead animals so that afterward when about to investigate the action and use of the parts (of the body) they quickly approach the living animal.

On the other hand since very many small parts of the body are endowed with different uses and functions, it is fitting that no one doubt that dissections of the living present also many contradictions.

The Uses of Bones and Cartilages Which May Be Seen in the Living Animal

Precisely concerning the bones; as we handle the individual bones, one after another, we request answers from the dissection of the living whether these are the best foundation and support of the body, and whether all things are attached to them and made firm. To be sure when we observe the bone of a living animal which has been broken by some accident, we perceive that the whole limb sub-

jectum collabi, neque amplius firmari intuemur: quod quia crebrius casu obvenit, in ossium usu indagando, vivorum sectionem non magnopere requirimus. Cartilagines quoque simili ratione quaedam firmare, quum franguntur, discimus: in articuli vero alicujus dissectione, videmus quid cartilago praestet, etiam si hanc in vivo animante non obeamus.atque ita etiam ligamenti ossa colligantis usus in mortuis quoque visitur, ut & ligamentorum etiam transversim tendinibus obductorum.dum enim transversum in brachialis interna sede positum ligamentum dividimus, musculumque digitorum secundos aut tertios articulos flectentem ad suum principium trahimus, id videmus in hoc potissimum factum, ut tendines, quo minus e sua sede exurgant, contineat. quanquam id in cane vivo etiam licebit cernere, si obiter cutem a cubito & manu liberaveris, & cultello transversum in brachiale ligamentum, & alia quae in externa ulnae & radii sede ad brachiale habentur, diviseris. mox enim quum canis suo impetu digitos flectet, & extendet, tendines e suis sinibus sublevari cernes. In hac etiam administratione musculorum actionem speculabere, quum illos in se, ubi maxime sunt carnei, colligi, crassescereque, & rursus produci gracilesque fieri videbis, prout collecti partem attrahunt, aut remissi eductique eam ab alio musculo in contrarium velli sinunt, aut etiam alioquin suam collectionem non exercent. Neque, id

Ligamentum usus.

Musculorum usus & functio qui spectentur.

jected to fracture collapses on itself and no longer gives support, and because such injuries happen more frequently by chance, we do not when examining the use of bones inquire particularly through the dissection of the living.

We learn also when certain cartilages are broken that they furnish strength in a similar manner. In truth we see in the dissection of any joint which cartilage may be displaced even if we do not observe this while the animal lives.

The Use of Ligaments

And likewise in the dead also one sees the uses of the ligament binding the bones together, and also that of the ligaments drawn across tendons. Thus, provided we divide the ligament placed transversely in the internal side of the foreleg and pull on the muscle flexing the second or third joints of the digits towards its origin, we discover that this tendon is so placed chiefly in order that it may hold the tendons together that they may not lift up from their bed. However it will be permitted to demonstrate this likewise in a living dog if thou shalt immediately free the skin from the elbow and paw, and shalt divide with a small knife the transverse ligament of the fore leg and the other parts which are held against the leg on the external side of the ulna and radius. Soon, forsooth, when the dog of its own volition flexes and extends its toes thou shalt see the tendons rise up from their sheaths.

The Use and Function of the Muscles Which May Be Seen

For in this demonstration thou shalt see the function of the muscles that of their own action they contract and become thick where they are most fleshy, and again that they lengthen and become thin according as they in combination draw up a limb, either letting themselves go back and having been drawn out permit the limb to be pulled in an opposite direction by another muscle, or at other times indeed they do not put in action their own combination.

hic in cubito duntaxat est observandum, verum altius ab eodem cane cutis est adimenda, ut brachium universum axillaque denudetur, & nervi per axillam in id prorepentes appareant: ex illisque aliquem laqueo intercipias, cuius seriem in musculos quosdam pertinere cognoveris. Verum quum canis nervorum numerus distributioque non admodum cum homine conveniat, suaserim, ut quum hanc sectionem in vivo cane obiturus es, mortuum quoque ad manum habeas, in quo nervorum per brachium & cubitum excurrentium seriem didiceris, atque ita nervum aliquem inveneris, qui in musculos quosdam digeritur: uti fere illi erunt, quorum alter in homine tertius est, ac secundum anteriorem cubiti articuli sedem in cubitum fertur: alter vero quintus, secundum posteriorem interioris humeri tuberis regionem in cubitum properans. Hujusmodi enim nervi in cane etiam observantur, & illis alicubi priusquam ad cubiti articulum pertingant ligatis, motus aboletur musculorum digitos & brachiale flectentium. unde si & illum nervum etiam vinculo interceperis, qui in homine mihi quartus numeratur, & secundum humerum ad externum ipsius tuber porrigitur, etiam motus abolebitur musculorum brachiale & digitos extendentium. Conduxerit autem hujusmodi nervos laqueis intercipere, quo illis modo in hoc, modo in illo nervo solutis, musculorum motum restitui observes. Jam musculo alicui muris forma donato (quales hic in cubito occurrunt plurimi) longam sectionem induces, quae ventrem totum penetret, ut musculi illius motum, hujus sectionis gratia non perdi expendas. Dum aut transversam

Nervi in musculis usus.

This is to be observed accurately at the elbow; indeed the skin of the same dog must be removed higher up in order that the whole leg [brachium] and axilla shall be bared, and the nerves running forward into it [the leg] through the axilla may become visible. Thou shalt perceive that a chain of these nerves reaches to certain muscles and thou shalt intercept some one among them with a noose.

The Use of the Nerve in the Muscles

In truth since the number and distribution of the nerves of the dog do not correspond exactly with those same in man I would advise when thou art about to perform this dissection in a living dog that thou hast at hand a dead one also in which thou shalt have separated the series of nerves running out through the foreleg and elbow, and thus thou wilt find some one of these nerves which is distributed to particular muscles. They will be arranged almost in this manner: In man one of them is the third, and is carried into the forearm along the anterior side of the elbow joint; another, in fact, the fifth, runs to the elbow next to the posterior portion of the internal tuberosity of the humerus. For in this manner the nerves are observed also in the dog. And these nerves having been tied somewhere before they reach the elbow joint, the motion of the muscles flexing the digits and arm will be abolished, and if thou wilt intercept with a band the nerve which in man is reckoned by me the fourth and is extended along the humerus to its external tuberosity, then the motion of the muscles extending the fore leg and digits will be abolished.

But on the contrary it will be useful to free the nerves in this observation from the ligatures in order that when these are untied thou shalt observe sometimes in this and sometimes in another nerve that the motion of the muscles is restored.

Immediately when any muscle has been given the form of a mouse (many such occur here at the elbow) thou shalt perform a longitudinal cut which shall penetrate its whole belly in order that thou mayest determine that the motion of that muscle is not lost on account of this incision.

sectionem ventri induces, tantum musculi motum aboleri videbis, quanta erit sectionis profunditas. Quum vero ventrem prorsus divides, musculum ad insertionem ipsius una parte, alia vero ad exortum colligi retrahique observabis. Quod si alterius alicujus musculi tendinem praescindes, musculum versus exortum convelli cernes. Item si caput diviseris, is ad insertionem contrahetur. Si vero insertionem & caput una abtruncaveris, musculus ad suum ventrem sedemque qua maxime carneus est conglobabitur: itaque musculorum functio tibi haec molienti erit obvia. Si aut privatim nervi alicujus, aut peculiaris musculi functionem inquirendam duxeris, eum nervum & musculum, ut jam in brachio & cubito faciendum praecepi, aggredieris. Neque est quod hic prolixe commemorem, qualiter in his administrationibus canes aut eius generis animalia ligare conveniat, quum quisque pro sua industria, si modo in mortuorum sectione adamussim versatus fuerit, haec omnia rectissime sit obiturus. Adeo ut de viva nervorum musculorumque sectione, nihil dicendum supersit, quanquam & de nervis recurrentibus paulo post quaedam nova sese offerente occasione subjiciam. Ut aut videas num nervi substantia, aut membranae illam induentes, animalem vim praecipue porrigant, opportune feceris, si cutem femoris tibiae & pedis auferas, ac primo femur moventium musculo a suis exortibus liberato,

Nervum usus examen.

On the other hand while thou performest a transverse section of its belly thou wilt see that the motion of the muscle is lost in proportion to the depth of the cut.

When in truth thou dividest the belly straight through thou wilt observe that the muscle draws together and contracts in one part towards its insertion, in the other portion towards its origin.

But if on the other hand thou shalt cut the tendon of any muscle thou shalt see that the muscle contracts towards its origin. Likewise if thou shalt divide the origin it will contract towards its insertion. If in truth thou shalt have cut the insertion and the head at the same time the muscle will be bunched at its belly and the portion where it is most fleshy, and thus the function of the muscles will be obvious to thee by the doing of these things.

If thou shalt desire to inquire especially into the function of any particular nerve or of a special muscle, thou wilt reach that nerve and muscle as I have already advised that it be done at the fore leg and elbow.

And I need not make mention in many words what this is, in what manner it will be fit in these experiments to tie up dogs or animals of this nature, since anyone shall accomplish all these things most correctly according to his diligence if he shall be skilled accurately in the dissection of the dead.

Examination of the Uses of the Nerves

As long as nothing remains to be said concerning the vivisection of the nerves and muscles, I shall submit a little later when some new opportunity offers something also concerning the recurrent nerves.

In order that thou mayest see whether the substance of the nerve or the membranes covering it especially conduct the "animal spirits," thou shalt do this conveniently if thou shalt lift the skin of the thigh, the shin and the foot, and having first freed the muscle moving the thigh from its

quartum femur petentem nervum inquiras: & hujus membranis a nervi substantia detractis, expendas quibus pedis digiti ipseque pes adhuc moveantur, ipseque nervus concreditum sibi munus adhuc utcunque exerceat. Verum si quis medullae dorsalis munus rimari statuisset, visurus quibus ea laesa, partes laesioni subditae sensum motumque perdant, huic licebit canem ita asseri cuipiam aut trunco alligare, ut dorsum cervicemque porrigat, quo dein grandiori cultro vertebrarum aliquot spinae praescindi queant, tandemque dorsalis medulla ea sede nudari possit, qua illam quis secandam arbitrabitur. nihil enim facilius est, quam tunc videre motum sensumque subditarum sectioni partium aboleri. Caeterum in venarum usu inquirendo, vix quoque vivorum sectione opus est: quum in mortuis affatim discamus, eas sanguinem per universum corpus deferre, & partem aliquam non nutriri, in qua insignis vena in vulneribus praescinditur. Item in arteriis, vivorum sectionem vix requirimus, quanquam licebit alicui arteriam in inguina procedentem nudare, vinculoque intercipere, ac intueri, partem arteriae vinculo subtensam non amplius pulsare. Atque ita levi negotio observatur in arteriis sanguinem natura contineri, si quando arteriam in vivis

Dorsalis medullae examen.

Venarum et Arteriarum usus Examen.

origins thou shalt search for the fourth nerve entering the thigh, and having removed the membranes from the substance of this nerve thou shalt seek out those by which the digits of the foot and the foot itself have up to this time been moved, and also the nerve itself that has up to this time performed whatever function belonged to it.

Examination of the Uses of the Dorsal Medulla

Even so if anyone may have considered examining the function of the dorsal medulla, it will be seen when the medulla has been injured how the parts below the injury lose sensation and motion. It will be permitted anyone to fasten a dog or to bind it to a block of wood in a way that one stretches out the back and neck. Therefore some of the spines of the vertebrae can be cut in front with a large knife and then the dorsal medulla can be laid bare in its bed, when anyone will get a view of the medulla about to be cut—for nothing is easier than thus to see that movement and sensation are abolished in the parts subjected to the section.

Examination of the Uses of the Veins and Arteries

Also when inquiring into the use of the veins the work is scarcely one for the dissection of the living, since we shall become sufficiently acquainted in the case of the dead with the fact that these veins carry the blood through the whole body and that any part is not nourished in which a prominent vein has been severed in wounds.

Likewise concerning the arteries we scarcely require a dissection of the living although it will be allowable for anyone to lay bare the artery running into the groin and to obstruct it with a band, and to observe that the part of the artery cut off by the band pulsates no longer.

And thus it is observed by the easy experiment of opening an artery at any time in living animals that blood is naturally contained in the arteries.

aperimus. Ut autem certiores fiamus, pulsandi vim non arteriae inesse, aut contentam in arteriis materiam pulsuum opificem existere, verum a corde eam virtutem pendere, praeterquam quod arteriam vinculo interceptam non amplius sub vinculo pulsare cernimus, licebit inguinis femorisve arteriae longam sectionem inducere, & canaliculum ex arundine tam crassum assumere, quanta arteriae est capacitas: & ita illum sectioni indere, ut superior canalis pars altius in arteriae cavitatem pertingat, quam sectionis superior sedes: & ita inferior quoque canalis pars, deorsum magis ipsa inferiori sectionis parte protrudatur: ac dein vinculum arteriae circundetur, quod ipsius corpus super canalem stringat. Quum enim id fit, sanguis quidem & spiritus per arteriam ad pedem usque excurrit, verum tota arteriae pars canali subdita non amplius pulsat. Soluto autem vinculo arteriae pars canali succedens, non minus quam superior pulsum ostendit. Quanta vero vis a corde per arterias cerebrodeducatur, postea videbimus: nunc Galeni vivam in hac demonstratione consectionem summopere mirantes, qua omnia praescindi suadet quae cerebro & cordi sunt communia: semper omittens arterias, quae per transversos vertebrarum cervicis processus caput petunt, & etiam non mediocrem portionem vitalis spiritus in primos durae membranae sinus, atque ita etiam in cerebrum deferunt: adeo ut non mirum sit, cerebrum diutius in illa administratione suo munere fungi, quam commode Galenus fieri arbitrabatur, respirat enim in hac sectione diutissime animal, & alias movetur.si vero currit, itaque multo spiritu indiget, non multo post concidit: quanquam adhuc postea cerebrum animalis

In order that on the other hand we may be more certain that the force of pulsation does not belong to the artery or that the material contained in the arteries is not the producer of the pulsation, for in truth this force depends for its strength upon the heart. Besides, because we see that an artery bound by a cord no longer beats under the cord, it will be permitted to undertake an extensive dissection of the artery of the groin or of the thigh, and to take a small tube made of a reed of such a thickness as is the capacity of the artery and to insert it by cutting in such a way that the upper part of the tube reaches higher into the cavity of the artery than the upper part of the dissection, and in the same manner also that the lower portion of the tube is introduced downward farther than the lower part of the dissection, and thus the ligature of the artery which constricts its caliber causes the cannula to encircle the closed artery.

To be sure when this is done the blood and likewise the vital spirit run through the artery even as far as the foot; in fact the whole portion of the artery replaced by the cannula beats no longer. Moreover when the ligature has been cut, that part of the artery which is beyond the cannula shows no less pulsation than the portion above.

We shall see next how much force is actually carried to the brain from the heart by the arteries. Now in this demonstration thou shalt wonder greatly at a vivisection of Galen in which he advises that all things be cut off which are common to the brain and heart, always excepting the arteries which seek the head through the transverse processes of the cervical vertebrae and carry besides a substantial portion of the vital spirit into the primary sinuses of the dura mater and also in like manner into the brain. So much so that it is not surprising that the brain performs its functions under these conditions for a long time, which Galen observed could easily be done, for the animal breathes for a long time during this dissection, and sometimes moves about. If indeed it runs, and therefore requires much breath, it falls not long afterwards although the brain will still afterwards receive the essence of the

spiritus substantiam recipiat, ab illis arteriis quas per transversos cervicis vertebrarum processus calvariam petere recensui. Caeterum hoc loco, ubi de vivorum sectione obiter tantum pertractandum duxi, haud proposui Galeni aut recte, aut minus recte celebratas vivorum sectiones commemorare: quum hic abunde fecero, si perfunctorie aliquot sectiones proferam singulis libris dicatas. Atque quum jam ad quintum usque sit deventum, modo de nutritionis organis sermonem instituemus, quorum munus fere in mortuorum sectione etiam discimus. Videmus enim peritonaeum omnium ipso complexorum organorum esse involucrum: omentum, ut & mesenterium, vasorum deductioni & distributioni optime subservire: ventriculum cibos & potum conficere, hosque per stomachum huc deferri. Quanquam & vivos canes, qui modo paulo aut multo ante cibum sumpserunt, vivos aggredi, atque ita etiam intestinorum munus rimari, nihil prohibeat. Jecoris autem officium, ut etiam lienis, aut renum, aut vesicae, in vivorum sectione vix melius quam in mortuorum intueri possumus. nisi quis vivo cani lienem execare voluerit, uti & ego aliquando feci, diebusque aliquot canem asservavi. Atque ita etiam renem aliquando execui: verum vulneris curatio molestior est, quam quae hinc sumitur cognitio jucunda. nisi quis non

Eorum quae peritonaeo continentur functionum examen.

animal spirit from those arteries which I have closely observed seek the skull through the transverse processes of the cervical vertebrae.

Besides in this place where I have considered that so much concerning vivisection ought to be investigated in passing, I have by no means proposed to comment on the celebrated dissections of Galen on the living either favorably or unfavorably since I shall do this sufficiently if I shall present in a formal manner some dissections appropriate to the [my] separate books.

Examination of the Functions of Those Parts Which Are Contained in the Peritoneum

And since the fifth book has been reached, we will begin a discourse concerning the organs of nutrition, with the functions of which also we commonly become acquainted in the dissection of the dead.

For we see that the peritoneum is a wrapper for all the organs enclosed in it; that the omentum and likewise the mesentery serve in the best manner for the conduction and distribution of the blood vessels; that the stomach prepares the food and drink, and passes these through the stomach onward.

And however nothing may prevent our taking living dogs which have consumed food at less or greater interval previously and examining them alive, and thus investigating the functions of the intestines. But on the contrary we are able to behold the functioning of the liver as also of the spleen or of the kidneys or of the bladder during the dissection of the living, scarcely better than in that of the dead; unless someone shall wish to excise the spleen in the living dog which I have once done, and have preserved the dog [alive] for some days.

And thus also have I once excised a kidney; in truth, the management of this wound is more troublesome than the pleasant knowledge which is acquired in the doing of it;

tam organorum cognitionis ratione has sectiones aggrederetur, quam ut manum exerceat, ac abdominis vulnera apte suere discat: quod & in intestinis studiose experiendum est, quo quis vulnerata consuere, atque in abdomen quum exciderint, imponere assuescat. Verum haec, perinde ac ossium luxationes & fracturae, quas in brutis aliquando molimur, exercendis potius manibus, & rectae curationi instituendae, quam organorum officiis indagandis conducunt. Porro vivas sectiones instrumentorum generationi subservientium, indies fere in ramicum curationibus, & in animalibus quae castrantur observamus. atque illae propemodum vasis seminariis & testibus spectandis sufficiunt: nisi quis illam quoque addere velit, qua cani ni testis substantiam ex tunica ipsi proxime obducta eximimus, aut etiam a seminariis vasis testis substantiam una cum illa tunica rescindimus. Verum in foetuum viva administratione jucundum est spectare, qualiter simulatque foetus aerem ambientem contingit, respirare nititur. Atque haec sectio opportune in cane aut sue obitur, quum non multo post sus est paritura. Si enim ipsius abdomen ad peritonaei usque cavitatem diviseris, atque dein uterum quoque in unius foetus sede aperveris, ac secundina ab utero liberata foetum mensae imposueris, cernes per pellucidas membraneasque ipsius tunicas, qualiter is frustra respirare conatur, & veluti suffocatus moritur. si vero foetus involucra pertuderis, ipsiusque caput illis

Generationis organum examen.

Foetuum examen.

unless one undertakes these dissections not so much for the sake of knowledge of the organs as in order to train his hands, and to learn to sew up wounds of the abdomen in a fitting manner; which should also be diligently practiced upon the intestines, in order to become accustomed to sew them up when wounded, and to replace them in the abdomen when they shall have slipped out.

In truth these operations, just as the dislocations and fractures of bones, which we sometimes do on brute beasts, serve more for training the hands and for determining correct treatment rather than for investigating the functions of organs.

Examination of the Organs of Generation

Furthermore, we commonly observe vivisections of the organs serving for generation from day to day in the treatment of hernia and in animals which are being castrated. These operations are almost entirely sufficient for observing the vasa seminalia and testes, unless anyone wishes also to add that dissection in which we remove in a dog the substance of the testicle from the tunic closely covering it; or even in which we resect the whole testicle together with the tunic itself from the seminal vessels.

Examination of the Fetus

Quite pleasing is it in the management of the fetus to see how when the fetus touches the surrounding air it tries to breathe. And this dissection is performed opportunely in a dog or pig when the sow will soon be ready to drop her young.

To be sure if thou dividest the abdomen of such an animal down to the cavity of the peritoneum, and then thou also openest the uterus at the site of a single fetus, and when the secundines have been separated from the uterus thou shalt place the fetus on a table, thou shalt see through its coverings and its transparent membrane how the fetus attempts in vain to breathe, and dies just as if suffocated. If in fact thou shalt perforate the covering of the fetus and shalt

liberaveris, mox illum veluti reviviscere, & eleganter respirare cernes. Atque quum id in uno foetu indagaveris, alium aggredieris: quem ab utero non liberabis, verum apertum ex dicta jam foetus administratione, uterum tantisper invertes, & prius factae sectionis labra extrorsum reflectes, dum alterius proximique foetus insima involucrorum pars sedesve appareat, & hanc ad eam usque regionem ab utero detegas, qua is exteriori foetus involucro connascitur: & qua ampla ea lienis substantiae similis caro habetur, quae vasa ex utero in exterius foetus involucrum pertinentia intertexit. Est enim hac administratione vasorum ille nexus integer asservandus, & reliquum exterioris involucri ab utero detegendum, ut per pellucida foetus involucra arterias per ipsa distributas & umbilicum subeuntes, ad uteri arteriarum rhythmum pulsare, & foetum respirationem nudum conari molirique cernas: ac dein effractis pertusisque involucris foetum tunc respirare, & involucrorum umbilicique arteriarum pulsum perire spectes, uteri arteriis adhuc cum reliquis extra ipsum arteriis pulsantibus. In cordis & pulmonis functionibus pleraque expendimus, motum videlicet pulmonis, & num aspera arteria eorum quae bibuntur portionem assumat: dein cordis dilatationem & constrictionem, ac num idem rhythmus sit pulsus cordis & arteriarum, item qualiter venalis arteria distendatur ac comprimatur, & quibus execto corde animal adhuc vivat. In quibus obser-

Cordis ipsique subministratium partium usus examen.

free its head from the coverings, thou shalt soon see that the fetus as it were comes to life again and breathes finely.

And when thou shalt have investigated this in one fetus thou shalt turn to another which thou shalt not free from the uterus but thou shalt invert the uterus opened by the same management as that of the fetuses just described, and shalt turn the edges of the dissection already made backward until the lower part or site of the coverings of another and nearest fetus shall appear, and thou shalt free this site from the uterus even up to that place where the uterus is fused in the exterior covering of the fetus, and where its abundant flesh will possess a substance similar to the spleen, which interweaves vessels stretching out from the uterus into the external coverings of the fetus.

For that network of vessels must be preserved intact during this manipulation, and the remaining external covering must be removed from the uterus in order that thou shalt see through the transparent covering of the fetus that the arteries distributed by the covering and running to the umbilicus pulsate in the rhythm of the arteries running to the uterus, and that the naked fetus attempts and struggles for respiration and thereupon when the coverings are punctured and broken thou shalt see that then the fetus breathes and that pulsations of the arteries of the fetal membranes and of the umbilicus stop. Up to this moment the arteries of the uterus are beating in unison with the rest of the arteries outside of itself.

Examination of the Function of the Heart and of the Parts Ministering to the Heart Itself

And we consider many things concerning the functions of the heart and lung; of course the motion of the lungs, and whether their rough artery [trachea] takes to itself a portion of those things which are inhaled; next, the dilatation and contraction of the heart, and whether the pulsation of the heart and arteries act in the same rhythm; also in what manner the venous artery is dilated and contracted, and whereby an animal continues to live after its heart has been

vandis, magnopere animali indigeremus lato pectoris osse donato, & membranas thoracem intersepientes tam distantes obtinente, ut diviso secundum longitudinem pectoris osse, sectionem inter eas membranas ad cor usque ducere possimus, citra thoracis cavitatum (quibus pulmones continentur) pertusionem. Verum quum nullum ejusmodi animal praeter hominem, & non caudatam simiam occurrat, in canibus ac porcis, illisque animalibus quorum nobis datur copia, sectiones ita sunt aggrediendae, ut praedicta omnia intuearis. Quod itaque pulmo thoracis motum sequatur, hinc patet, quod sectione in aliquo costarum intervallo ad thoracis usque cavitatem ducta, laesi lateris pulmonis pars concidat, neque amplius cum thorace distendatur, reliqua adhuc pulmonis parte thoracis motum sequente: quae etiam mox concidet, si & in altero latere sectionem in thoracis usque cavitatem molieris. atque ita animal, etiamsi thoracem aliquandiu moveat, non minus morietur, quam si suffocatum esset. Verum in hac administratione observandum venit, ut sectionem quam proxime ad superiorem alicujus costae ducas sedem, ne ad inferiorem forte, sectionem dirigens, vasa hac exporrecta pertundas. tum enim sanguis illinc profluueret, qui aeris per vulnus immissi & emissi gratia, spumosus redditus, pulmonis loco tibi imponeret. Incaute enim secantibus ejusmodi spuma pulmo esse videtur, ipsique pulmonem aliquandiu etiam sua insita vi distendi opinantur. Ut vero naturalem pulmonis cum thorace sequelam videas, ex altero latere duarum aut trium mediarum costarum cartilagines dissecabis: & sectionibus per illarum costarum intervalla ductis, singulas

excised. For making these investigations we particularly require an animal endowed with a wide breastbone and possessing membranes dividing the thorax separated in such a way that when the sternum has been divided lengthwise we may be able to carry the dissection between these membranes even to the heart itself without causing a perforation of the cavities of the thorax in which the lungs are contained.

Indeed, when no such animal except man or a tailless ape is to be had, these dissections must be carried out in dogs and pigs and those animals of which an abundance is furnished us, as thou has seen all this mentioned above.

Therefore and in like manner the lung follows the movement of the thorax. It is evident from this why when a cut is made in an intercostal space penetrating the thoracic wall, that the portion of the lungs on the injured side collapses, and distends with the thorax no longer. While until then the other lung, following up to this time the movement of the chest also soon collapses if thou shalt make a cut penetrating even into the cavity of the thorax on the other side. And then the animal, even if it moves the chest for some time, will die nevertheless just as if it were suffocated.

In fact it ought to be observed in this demonstration that thou shalt make the cut as close as possible to the upper edge of any rib lest thou mayest direct the incision by chance along the lower edge and perforate the vessels stretched along there. For the blood will flow forth thence at once, which rendered frothy in consequence of the air inhaled and exhaled through the wound, will appear to thee falsely as the lung, for this froth will appear to be the lung to those who dissect carelessly, and they will think that the lung is distended on such occasions by its own inherent force.

In order that thou mayest see the natural relationship of the lung to the thorax, thou shalt cut the cartilages of two or three median ribs from the opposite side, and when the incisions have been carried through the interspaces of

costas extrorsum reflectes, ipsasque franges, quo opportunam constituas sedem, per quam lateris illae si pulmonem videre queas.quum enim thoracem intercipientes membranae in canibus admodum pellucidae sint, perfacile est, per eas pulmonis partem thoracis motum adhuc sequentem intueri, ac illis etiam membranis leviter pertusis considerare, qualiter & ea pulmonis pars intercidat. Priusquam tamen eas pertundas, conduxerit arteriae venalis propagines in eam pulmonis partem, quae jam concidit, manibus apprehendere, & aliquousque ab ipsis substantiam pulmonis liberare: ut discas, num illae perinde atque cor moveantur. Cordis enim motus etiam hic tibi est conspicuus, praecipue si cordis involucrum diviseris, & ab illo cor in eo latere detexeris, ubi hanc administrationem moliris. Conduxerit vero hanc in sinistro latere tentari, ut scilicet dextra pulmonis pars adhuc moveatur, & una universum arteriae venalis truncum manu commode apprehendas. In hujusmodi quoque administratione non inutiliter cordis basim amplecteris, unoque vinculo vasa ab ipsa prodeuntia simul & ocyus intercipies, ac dein sub vinculo cor execabis, solutisque quibus animal colligatum est laqueis, currere sines. Vidimus enim aliquousque etiam ita affectos canes, sed praecipue feles, cucurrisse. Caeterum cordis motus, ut & arteriarum, rectius spectabis, si mox atque canem asseri alligaveris, sectionem a jugulo per costarum cartilagines, qua illae ossibus continuantur, in utroque latere acuto admodum cultro duces, ac mox ab unius sectionis fine transversim ad finem alterius sectionis, tertiam

these ribs thou shalt bend the separate ribs outward and break them where thou shalt decide to be the proper place through which thou seekest to observe the lung of the uninjured side, for since the membranes dividing the thorax in dogs are sufficiently translucent, it is very easy to inspect through them the portion of the lung which is following up to this time the movements of the thorax, and when these membranes have been perforated slightly, to consider in what manner that part of the lung collapses.

Before thou perforatest these membranes it will have been useful to grasp with the hands the branches of the venous artery in that part of the lung which now collapses, and in some other portion to free the substance of the lung from those vessels in order that thou mayest learn whether these vessels and the heart are moved in like manner.

For the movement of the heart is evident to thee even here especially if thou shalt divide the covering of the heart and shalt uncover the heart from it on that side where thou art carrying on this operation.

It will be fitting to try this on the left side as of course the right part of the lung may be lifted up to the point and at one time thou mayest conveniently grasp the main trunk of the venous artery easily in the hand. Also thou mayest in an operation of this kind carefully handle the base of the heart, and may cut off swiftly and at one time and with one ligature the vessels from their origins, and then thou mayest cut to excise the heart under the ligature, and when the bands have been loosened with which the animal has been tied, thou mayest allow it to run about.

Indeed we have at times seen dogs, but especially cats run about when treated in this manner.

Besides thou wilt see the movement of the heart and also of the arteries more accurately if soon thou shalt bind the dog to a plank, and shalt carry the incision on both sides with a very sharp knife from the clavicle through the cartilages of the ribs where they are continuous with the bones, and thou shalt make a third incision even into the

sectionem in peritonaei usque cavitatem molieris, & levato pectoris osse cum ipsi coarctatis cartilaginibus, & septo transverso ab iis liberato, pectoris os ad animalis caput sursum reflectes: ac mox diviso cordis involucro, una manu cor apprehendes, & alia arteriam magnam dorso exporrectam continebis. Quanquam & haec omnia melius obibis in ea viva sectione, quam inter alias utpote uberiorem in scholis exhibere consuevi. atque hanc ideo, simulatque nonnulla de cerebro subjunxero, perscribam prolixius, ut ab aliis leviori negocio quoque aggrediatur. In cerebri igitur ipsiusque partium examine, parum omnino in viva sectione videndum est, quum hic velimus nolimus, vel theologorum nostratium causa, memoriam, rationem & cogitationem brutis animalibus adimere debeamus, utcunque illis cum homine eadem sit constructio: atque ita Anatomes studiosus, & in mortuorum sectione versatus, nullaque haeresi infectus, probe intelligit, quam male mihi consultum velim, si quod alias longe lubentissime facerem, de cerebri viva sectione aliquid instituerem. Quod tamen ad sensum & motum attinet, videre est, cerebro ablato utrunque perire. Atque hic eadem indagandi est ratio, quam in nervorum administratione praecepimus. Num vero cerebrum sentiat, in homine venit investigandum: qui quum id

Cerebri functionum examen.

cavity of the peritoneum transversely from the end of one of the above incisions to the end of the other; and when the sternum has been lifted with its cartilages pressed to it, and when the transverse incision has been freed from them, thou shalt turn the sternum upward towards the head of the animal and soon when the covering of the heart has been opened thou shalt grasp the heart with one hand and with the other thou shalt take hold of the great artery extending into the back.

And although thou shalt accomplish all these things better in that vivisection inasmuch as I have been accustomed to demonstrate this among other things more fully in the schools, and therefore I shall write later about this more fully and at the same time I shall have added something concerning the brain in order that it also may be approached by others with less trouble.

Examination of the Function of the Brain

In the examination of the brain and of its parts therefore entirely too little is to be seen in the dissection of the living, whether we desire it so or not, or whether in deference to the opinion of our present-day theologians we ought not to deprive brute beasts of memory, of reasoning and of meditation, how much soever their structure may be the same as in man. And thus one who is studious of anatomy and skilled in the dissection of the dead, and uninfluenced by any heresy, understands honestly how badly I may wish advice for myself if and what I may most gladly carry on at some future time, and what I may undertake concerning any vivisection of the brain.

What indeed concerns sensation and motion, it is evident that both cease when the brain has been removed.

And the same method [experimental] ought to be pursued in this case, which we advised in operation on the nerves.

Whether in truth the brain feels ought to be investigated in man, who may indicate whether he feels pain when

scinditur, aut premitur, indicet num dolore afficiatur, numve quo cerebrum alteratur, sentiat: uti in capitis vulneribus indies experiri integrum est. Rursus calvariam canis posse frangi, & cerebri ventriculum aut dextrum aut sinistrum aperiri, ac quibus animal motum perdat, illumque denuo occluso ventriculo recipiat, neminem ambigere arbitror. Porro sectionem quam me descripturum paulo ante pollicebar, in praegnante cane, aut sue aggredieris: quanquam vocis occasione suem accipere magis conveniat. canis enim aliquandiu ligatus, utcunque illum afficias, subinde neque latrat, neque ululat: itaque vocis ablationem aut resolutionem interdum expendere nequis. Primum igitur animal ut supinum jaceat, anterioremque colli sedem, & liberum corporis truncum porrigat, asseri ita quam poteris validissime pro tua industria rerumque copia, alligabis. Non enim arduum est, asserem quempiam sumere, cui foramina insint ligandis cruribus apta: aut si nulla adsint foramina, prompte asseri duo baculi subjiciuntur, illisque crura advinciuntur. Inter caetera

Viva Sectio qua Anatomes speculatione in Scholis colophon adhiberi Solet.

H A C figura suem asseri, quem vivis sectionibus administrandis parare solemus, ac ultimo primi libri capite cum reliquis anatomicis instrumentis proposuimus, alligatam conspicis, ut modus quo in nostris scholis utimur, aliqua ex parte foret obvius.

the brain is cut or pressed upon, or whether he may perceive by what the brain is affected as is thoroughly put to a test daily in wounds of the head.

Again I think that no one doubts that the calvarium of a dog may be broken and the ventricle of the brain, either right or left, be opened from which the animal loses motion and regains it when the ventricle is closed again.

A Vivisection Which It Is the Custom to Use in the Schools at the End of a Demonstration of Anatomy

Furthermore thou shalt begin the dissection of a pregnant dog or pig as I promised to describe a short space above. It is more convenient to select a pig because of the favorable action of its voice for however much thou mayest suddenly injure a dog which has been bound for some time he neither barks nor howls, and thus thou art unable in the meantime to observe the loss or restoration of the voice. At first therefore thou shalt tie the animal to a plank in such manner that it may lie on its back and may stretch the anterior surface of the neck and the free trunk of its body as thou wilt be able most effectively to accomplish many things through thy work. For it is not difficult to take any plank in which there may be holes suitable for tying the legs or if there are no holes, two cleats may be quickly placed under the plank, and the legs be bound to these.

In this figure thou seest a pig bound to a plank as we are accustomed to prepare one for performing a vivisection, and we have displayed in the last chapter of the first book the remaining anatomical instruments in order that the method which we use in our lectures shall partly be made evident.

autem, superioris maxillae praecipua habenda est ratio, ut illa valide asseri firmetur. quod feceris catenula, aut corda quapiam robustiore ante dentes caninos ligata, ac dein cuipiam asseris anulo, aut foramini, aut ut commodius duxeris commissa, ut scilicet collum exporrectum, caputque immotum sit, & interim animal libere respiret clametque. Priusquam vero animal ita vincitur, spectatoribus jam in mortuorum Anatome versatis recensere soleo, quae nam potissimum praesenti sectione sint videnda, ne prolixa intersecandum dein enarratio operi obsit, idque forsitan dicendo interturbetur. Mox itaque longam in collo sectionem acutiori novacula duco, quae cutem & subjectos illi musculos ad asperam usque arteriam dividat: id cavens, ne sectio in latus aberret, venamque notatu dignam vulneret. dein manibus arteriam asperam comprehendo, & illam ab incumbentibus musculis digitorum duntaxat opera detegens, ad hujus latera soporales arterias, illique attensos sexti paris nervorum cerebri nervos perquiro. dein recurrentes nervos lateribus asperae arteriae adnatos etiam observo, quos interdum laqueis intercipio, interdum praescindo: idque primum ex altero latere, ut nervo hic intercepto praesectove dilucide observetur, quibus media vox pereat, totaque ambobus nervis laesis intercidat: & si laqueos solvo, rursus redeat. id enim cito & citra insignem sanguinis fluxum expenditur, ac pulchre auditur, quam validam efflationem animal citra vocem moliatur, recurrentibus nervis cul-

Nervorum recurrentium examen vocisque eorum sectione abolitio.

Among other things also an especial method should be used for the upper jaw in order that this shall be made fast firmly to the plank. Thou shalt do this with a small chain or any strong cord tied in front of the canine teeth, and to any ring or hole of the plank or fastened as thou shalt have arranged more suitably in order of course that the neck may be stretched and the head motionless, and at the same time the animal breathe and cry out freely.

In fact, before the animal is bound in this manner, I am accustomed to ascertain that the spectators are skilled already in the dissection of the dead, above all in those things which are chiefly to be seen in the present dissection, lest prolonged interpretation during the dissection may hinder the work and this by chance be interrupted by talking.

Examination of the Recurrent Nerves and the Loss of Voice from the Cutting of Them

And soon I begin in this wise an extended dissection in the neck with a rather sharp knife which divides the skin and muscles lying under it right to the trachea, avoiding this lest the incision may deviate to the side and wound especially the principal vein. Then by grasping the windpipe with the hands, and freeing it accurately from the overlying muscles by the use of the fingers as far as the arteries lying at its side; I seek out the nerves bordering upon the sixth pair of cerebral nerves; then I note the recurrent nerves lying on the sides of the rough artery [trachea] which I sometimes intercept with ligatures, at other times I cut. And first I do the same on the other side, in order that it may be clearly seen when one nerve has been tied or cut how half the voice disappears and is totally lost when both nerves are cut. And if I loosen the ligatures that the voice will return again. For this is carried out quickly and without an unusual loss of blood, and it is clearly proved how the animal struggles for deep breaths without its voice when the recurrent nerves have been divided with a sharp knife.

tello divisis. Hinc ad abdomen venio, & acuta validaque novacula sub spuriarum costarum cartilaginibus, mucronataque pectoris ossis sede sectionem instar semicirculi uno ductu ad peritonaei usque cavitatem molior: ex cujus sectionis medio ad pubem usque aliam tento, quae prompte succedit, si cultrum aut novaculam peritonaei cavitati indem itaque intestina & uterum foetibus distentum duabus illis sectionibus detegem, id sedulo studens, ut astantium quidam pollicem vasis obdat, quae sub pectoris osse descendentia abdomen petunt. illa enim sola hactenus multum sanguinis fundunt. Hic modo sectioni viciniores hortor, ut manu septo transverso adhibita, ipsius motum experiantur: dissitos aut, ut ventriculi & jecoris veluti in thoracis cavitatem assumptionem & dimissionem spectent. Interea in altero thoracis latere longam sectionem ad costarum usque ossa duco, ad eam fere regionem, qua costae in cartilaginem degenerant. & dein secundum costarum ossa transversas sectiones molior, ut ossa incumbentibus musculis aliqua ex parte liberem: & insuper si operosiorem administrationem sequi visum sit, intercostales musculos in duobus costarum intervallis a tunica costas succingente auferam, ut dein mediam inter illa intervalla costam solarum manuum auxilio a tunica costas succingente avellam: illaque a sua cartilagine fracta, & deorsum in latus inflexa, magna tunicae costas succingentis appareat amplitudo, quae pellucida pulmonis motum utcunque commonstret. Hac postmodum pertusa, videtur quibus hujus lateris pulmo concidat, thorace interim

Septi transversi functionis examen.

From this point I arrive at the abdomen, and I make an incision to the cavity of the peritoneum in the form of a semicircle with one stroke of a sharp and strong knife below the cartilages of the false ribs and the pointed end of the sternum. From the center of this incision I try another to the pubes, which quickly follows if I shall introduce the knife or razor into the cavity of the peritoneum, and thus I shall uncover by these two incisions the intestines and the uterus distended with young. Studying this carefully in order that some one of those standing by may place a thumb on the vessels which descending under the breast bone seek the abdomen, for only these carry much blood to this region.

Examination of the Functions of the Diaphragm

In this wise I advise those standing near the dissection that they watch the movement of the diaphragm when it is held in the hand, and those at a distance that they observe the expansion and contraction of the stomach and liver similar to the movements in the cavity of the thorax.

Meanwhile I carry on an extensive dissection on the other side of the thorax to reach the bones of the ribs even nearly to that point where the ribs change into cartilages. And then I make transverse incisions along the bones of the ribs in order that I may free the bones in some part from the overlying muscles; and if it is seen that further painstaking work may follow I lift the intercostal muscles of two intercostal spaces from the tunic covering the ribs that I may thus tear away the intervening rib from the covering surrounding the ribs with the help of my hands alone. And when that rib is broken from its cartilage and bent backward on the side, the great size of this tunic surrounding the ribs will be apparent. This transparent covering will demonstrate however the movements of the lung. After this covering has been punctured it will be seen how the lung collapses on this side although the thorax moves meanwhile just as before.

Pulmonis motuum examen.

aeque ut prius moto. Ut vero id magis reddatur conspicuum, plura costarum ossa a suis cartilaginibus libero, quam possum maxime hoc thoracis latus aperiens, ut commode per membranas thoracem intersepientes, altera pulmonis pars, quae in thoracis cavitate nondum laesa, pulchre cum thorace movetur, sese offerat: ac deinceps illis membranis pertusis, haec quoque mox a perforatione concidere & collabi videatur. Nunc in altero etiam latere acutiori cultro, una sectione costarum ossa a cartilaginibus libero, & a cartilaginibus pectorisque osse septum transversum reseco, ut cum cartilaginibus, os illud divulsis thoracem intersepientibus membranis, sursum ad collum reflecti queat, cordisque involucrum in conspectu sit. quod ilico cultello aperiendum est, observandumque, quantum aquae contineat, & quibus cor agatur. Verum cordis motui non diu animum adhibebis, quin potius animali jam fere propter concidentem undique pulmonem suffocato succurres: ut dein adamussim rursus cor arteriasque, & foetus in utero contentos, quamdiu visum erit, examines. Hactenus enim sanguinis fluxus parum incommodi animali intulit, si modo illa quae sub pectoris osse repunt vasa astans aliquis obturaverit, ac pectoris os jam sursum ad collum reflexum jaciat, itaque ob vasorum obliquitatem illa nihil amplius fundant. quod & in vasis costis singulis ex-

Aquae in cordis involucro repositae & cordis motuum examen.

Examination of the Movements of the Lung

In fact in order that this may be made more evident I free many bones of the ribs from their cartilages, opening this side of the thorax as much as I am able in order that there may be presented through the membranes dividing the chest, the other part of the lungs which shows itself and being in the hitherto uninjured part of the thorax, moves well with it. And then when these membranes have been punctured this part also is soon seen to collapse from the perforation, and to fall together.

Examination of the Water Contained in the Pericardium and of the Movements of the Heart

Now also on the other side I free by one incision with a very sharp knife the bones of the ribs from their cartilages, and dissect the diaphragm from the cartilages and from the sternum in order that when the membranes dividing the thorax have been torn apart, the sternum with the cartilages may be bent back and upward towards the neck, and the covering of the heart may be in sight. The pericardium ought to be opened at this place with a small knife, and it should be observed how much water it may contain, and how the heart acts.

In truth thou wilt not for some time give a thought to the motion of the heart but thou shalt rather come to the aid of the animal now almost suffocated because of the collapsed lung in order that thou mayest accurately examine the heart and arteries again and the fetuses contained in the uterus for as long as [the animal] is to be observed.

Thus far indeed the loss of blood has brought little inconvenience to the animal if any one standing near shall obstruct those vessels which run under the sternum, and shall turn the sternum already bent upward towards the neck; thus on account of the bending of the vessels these vessels lose blood no longer, and the same will occur in the vessels when the separate ribs have been stretched as

porrectis fit, quum costae effractae deorsum evertuntur: ipseque, dum sectionem administras, vasa tantisper dum obliquentur occludere adnisus fueris. Ut vero vita animali quodammodo restituatur, foramen in asperae arteriae caudice tentandum est, cui canalis ex calamo aut arundine indetur, isque inflabitur, ut pulmo assurgat, ipsumque animal quodammodo aerem ducat. levi enim inflatu in vivo hoc animali pulmo tantum quanta thoracis erat cavitas intumet, corque vires denuo assumit, & motus ipsius differentia pulchre evariat. Inflato igitur semel atque iterum pulmone, cordis motum visu tactuque quantum lubet examinas, & arteriae magnae caudicem dorso explicatam, aut in thoracis cavitate, aut ad lumborum vertebras comprehendis, & spectas pariter: nihilque tibi manifestius occurrit, quam cordis & arteriarum pulsuum rhythmus.quo aliquandiu observato, pulmo rursus inflandus est: hocque artificio, quo mihi gratius in Anatome nullum comperi, magna pulsuum differentiarum cognitio paranda venit. Quum enim pulmo diu flaccidus concidit, undosus, formicans, & vermicularis cordis arteriarumque pulsus motusve spectatur. inflato aut pulmone, magnus rursus & velox efficitur, mirasque inaequalitates proponit: &, ut semel dicam, haec administratio ejusmodi est, qua omnium optime pulsuum naturam medicinae candidatis proponere

Num cordis et arteriarum par pulsus fit examen.

for example whenever the broken ribs are everted backwards. While thou art carrying on the dissection thou shalt have taken pains to close off the vessels as long as they are bent.

In truth in order that the life of the animal may be revived in a certain manner, an opening must be made in the main stem of the trachea in which a pipe made of a reed or cane is introduced, and this is inflated so that the lung is expanded and the animal itself may secure air in some way, for the lung in this living animal expands to an extent equal to the cavity of the thorax and the heart takes on its powers again, and the change alters its action for the better.

Examination Whether the Pulsation of the Heart and Arteries Is Coincident

Therefore when the lung has been inflated again and again, thou mayest examine the movement of the heart by sight and touch as much as is desired. And thou graspest the trunk of the aorta extended in the back or in the cavity of the thorax or along the lumbar vertebrae, and thou shalt see in like manner, and nothing seems more evident to thee than the rhythm of the beating of the heart and arteries.

When this has been observed for some time the lung must be inflated again. From this observation the important recognition of the differences of the pulses comes to be determined than which nothing in anatomy can be learned which is more pleasing to me.

For when the lung being flaccid for a long time collapses, a wavy, creeping and wormlike pulsation or movement of the heart and arteries is to be seen. Or when the lung has been inflated, a large and rapid pulsation is again established and discloses extraordinary irregularities. And as I shall say just once, this procedure is of that kind by which I am accustomed best to explain to candidates in medicine the nature of all pulsations.

Foetuum examen.

soleo. Verum in horum examine foetuum gratia nunc non diu haereo, sed in aliqua bicorni canis suisve uteri sede, sectionem super foetum aliquem duco ad exterius ipsius usque involucrum penetrantem: quo deinceps ab utero divulso, foetum cum suis involucris eximo, & exteriori effracto involucro, per interius valde pellucidum ostendo, quibus foetus respirare conetur, quamque pulchre interiori quoque involucro fracto aerem ducat. Mox proximum foetum, quantum possum detego, uterum nulla ex parte ab exteriori involucro divellens, ut hic ita foetus vasorum natura examinetur, uti prius vivam foetuum dissectionem faciendam praecepi. Quum haec molior, per intervallaque pulmonem inflari curo, nondum cordis & arteriarum motus latet, verum longo admodum tempore animalis vitae succurritur, & cordis auricularum motus etiam prompte expenditur, perinde ac arteriae venalis, & venae arterialis: quas si non sat sit proxime ad cor tetigisse, in aliqua pulmonisfibra ipsius substantiam a vasis unguibus discerpo, & quod hic animadvertendum est, observari sino, dextrum postea cordis aperiens ventriculum, quo constet, quibus cor illo etiam patente, nihilominus moveatur.

Arteria Venalis & venae arterialis motuum examen.

Examination of Fetuses

In truth now I do not willingly delay for long the examination of these fetuses but I make an incision over a fetus in some part of the bi-horned uterus of the dog or pig, which extends down to the external covering of it. When this has been removed from the uterus, I remove the fetus with its covering, and when the external covering has been torn I demonstrate through the very transparent interior membrane how the fetus attempts to breathe, and how it receives air when the inner membrane has also been ruptured.

Soon I uncover the next fetus as much as I can, separating the uterus from the exterior covering in no part in order that the nature of the vessels of the fetus may be examined in such manner as I have advised previously that the vivisection of fetuses ought to be done.

Examination of the Movements of the Venous Artery and of the Arterial Vein

When I undertake these examinations I take notice even through the [intercostal] interspaces that the lung is inflated, while the movement of the heart and arteries is still visible. In truth the animal has been kept alive in a way for quite a long time, and besides the movement of the auricles of the heart has been quickly investigated just as also that of the venous artery and of the arterial vein. If it [the opening] is not sufficiently near to the heart to have touched these, I tear into some fibers of the lung and [separate] its substance from the vessels with my nails, and I present for observation that which ought to be considered here, opening the right ventricle of the heart posteriorly particularly where it remains motionless, how the heart, even after it has been opened, moves nevertheless.

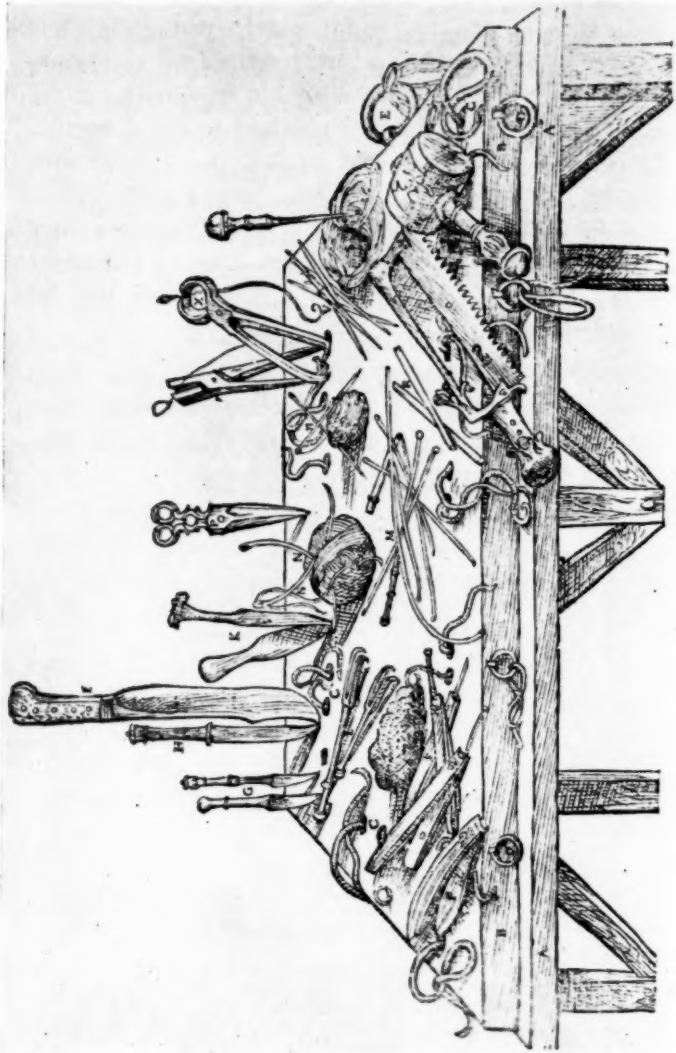
Sinistro insuper ventriculo una adaperto, aut media cordis parte transversa sectione ablata, spectatores moneo, ut auricularum cordis motum nondum quiescere intueantur. Dein si animali ante sectionem potum colore aliquo infectum porreximus, idque cibos varios seriatim ingesserit, cujusmodi humor in pulmonis asperae arteriae ramis occurrat, quaeque ciborum in ventriculo sit series, perquiro: hac dissectione, toti Anatomicae speculationi colophonem in nostris scholis perinde addens, atque huic meae de Humani corporis fabrica historiae nunc illa finem impono.

SEPTIMI ET ULTIMI LIBRI FINIS.

Besides when the left ventricle has been freely opened at the same time, or when the middle portion of the heart has been removed by a transverse cut, I remind the spectators that they observe that the movements of the auricles of the heart do not stop yet. Later if previous to the dissection of the animal we have offered to it a drink dyed with some color or the animal shall have partaken of various kinds of foods, one after another, a liquid of the same color exists in the branches of the rough artery of the lungs [trachea], and I investigate what series of food may be found in the belly.

Quite as adding a colophon to the whole anatomical demonstration in our schools with this dissection, just so with the same I now place an end also to this: my treatise concerning the structure of the human body.

END OF THE SEVENTH AND LAST BOOK



The instruments of Vesalius for dissection of the dead and of the living animals exhibited on an animal plank for vivisection.

THE PHYSIOLOGY OF VESALIUS

ESALIUS up to the age of thirty was distinctly an anatomist, and in ending his treatise on the structure of the human body with a chapter "On some dissection of the living," he expresses at once his preference for the study of the dead as a source of knowledge not only of structure but also of function. However, in his description of the use of the ligamentous bands at the wrist and ankle he abandons the dead body, and demonstrates the function of the annular ligaments not only by cutting one on a living dog but also with a simple application of cords on the ankle of a man showing that a cord tied to the big toe, if loose, pulls the ankle but if restrained by a band at the ankle pulls the toe only. Vesalius emphasizes his opinion that skill in vivisection is assured by an accurate experience in the dissection of the dead, and advises the use of a specimen dissection of the nerves in a dead dog to control and direct the progress of a vivisection of the same region. In general when describing his vivisections Vesalius records his results only, and draws few conclusions and formulates no theories or explanation of the facts observed. For instance, he calls attention to the loss of motion from ligating the nerve running to a muscle, and also the restoration of movement from cutting the ligature. He does not describe his

results in detail but leaves it to the operator to demonstrate these as they occur in his own vivisection. He describes the effects of loss of motion and of sensation below a transverse section of the spinal cord but does not repeat the more elaborate experiments on the spinal cord attributed to Galen more than thirteen hundred years before. He usually describes the methods of procedure only.

Vesalius errs in his observation that the fetal pulse in the umbilical cord pulsates in rhythm with the pulse of the uterine blood vessels, possibly because he is observing in his experimental animals a general circulation which had been accelerated by the shock of the operative procedure of the precedent vivisection. Vesalius observes correctly that the vessels of the uterus pulsate synchronously with the other arteries of the animal, and that the vessels of the fetal envelopes and of the umbilicus cease to pulsate as soon as the fetus breathes, even if the fetus is still attached by the umbilical cord to the uterine wall.

He records accurately that either lung collapses only after each pleural cavity is punctured, and that the animal dies of suffocation if the pleurae on both sides are punctured at the same time in spite of continued movements of the chest wall, and that the animal will revive for a while if air be blown into the incised trachea at intervals imitating the rhythm of normal respiration. Vesalius proves that an artery ceases to pulsate beyond a ligature, and that pulsation is resumed if a cannula made of reed or cane is made to connect the two parts of the artery above and below the ligature. But he failed to make any similar experiments on the veins. He follows Galen when emphasizing that pulsation is one of the chief characteristics of living tissue and attributes the flow of blood in arteries and veins to the power of suction caused by their pulsation. William Harvey refers in his second letter to Riolanus to this experiment of Vesalius inserting a cannula around a ligated artery as a positive proof of the circulation of blood, and that the pulse is due entirely to the intermittent flow of blood as pumped by the heart and is not transmitted from the heart by the walls of the vessels.

Vesalius gives useful surgical directions to avoid the intercostal blood vessels which are located along the lower borders of the ribs, and describes the difficulties of technique and errors of judgment which may result from haemorrhage from this source. He never suggests controlling haemorrhages from smaller vessels by the use of a ligature, which procedure was rediscovered and introduced into surgical practice by his contemporary, Ambroise Paré, as recorded by Malgaigne in his Edition of Paré (1564). Although Vesalius used a ligature to control the vessels entering and leaving the heart when repeating the older experiment of Galen, in which the heart is excised during the life of an animal, he controlled haemorrhages from the intercostal arteries only by bending them. Vesalius pleads for advice concerning any possible plan to permit future work on cerebral function which he might wish to undertake on the brains of living animals. First, he belittles what can be learned by such vivisection, then he complains of the objections raised by the theologians of his day who denied the right of man to take away even from dumb beasts their memory and powers of reasoning and of meditation. This professional criticism by his contemporary antivivisectionists sounds not unfamiliar to the scientists of today, who practise animal experimentation, except that at present the attack on this branch of the scientific study of medicine is more radical and would impose a total prohibition of such work although the animals used in modern laboratories are fully anaesthetized during operative procedures. Vesalius explains that the brain controls motion and sensation, and that when the brain is removed these are lost, and the animal dies at once. He previously had shown that an animal could walk about for an appreciable period of time after the heart had been excised. These two experiments were carried out to repeat the proof of Galen that the soul resided in the brain, and not in the heart as had been claimed by Aristotle. Vesalius emphasized that the cavities of the brain are the seat of cerebral function, which depends on the formation of the animal spirit (from

anima, the soul) by a "coction" in the ventricles, and the transmission of this *spiritus* to the muscles and other parts of the body by the nerves acting as connecting tubes similar to the action of the veins and arteries. Having explained that he cannot describe any experimental dissections of the brains of animals because of opposition by the church, he recites, as if from his experience with accidental fractures of the skull of man, the results of opening the ventricles of the brain, and closing them again. One may suspect that Vesalius is not wholly frank, and that this alleged knowledge comes in large part from experiment on animals, probably performed in secret and similar to those reported by Galen some thirteen centuries previously, but as he gives no clue to the incisions made or to the position of the injuries to the brain tissue by which the interior of the cerebral ventricles is exposed, it is impossible to draw in terms of modern cerebral physiology any inferences from his text as to what symptoms should follow the cases which he suggests that he has seen.

Vesalius accepts the Galenic theory that the veins carry nutritive blood with its natural spirit from the liver through the whole body, and that any part loses nourishment in which a principal vein has been accidentally cut. He considers it necessary to reaffirm the teaching of Galen, that the arteries contain blood, by demonstrating the presence of blood in the arteries during life by the simple experiment of cutting an artery in a living animal. Vesalius also denies that vivisection is required to prove the function of the arteries, and follows the teaching of Galen that these vessels carry from the heart to the distant tissues the blood plus the vital spirit which has been furnished to it in the left ventricle of the heart. He then proceeds to describe a careful experiment proving that the blood plus this vital spirit can reach the foot through a cannula inserted around a ligature of the femoral artery. Vesalius fails to try the same experiment with a cannula on a vein, or even with a ligature, and therefore learns nothing newer than the physiology of Galen concerning the circulation of the blood from

his vivisections, although his experiment, if understood, proves the circulation of the blood. The results of tying a vein were recorded first in print by Caesalpinus in 1571.

Nevertheless, Vesalius revolts from the opinion of Galen, and expresses doubt concerning the existence of pores in the septum of the heart. He says, in both the first and second editions, "The surface of each ventricle is extremely uneven and beset with numerous pit-like indentations deeply sunk in its fleshy substance. These pits, however, are not confined to the side by which the right ventricle corresponds with the left (notwithstanding it is so understood by all other anatomists), but are found over the whole ventricular surface." (Translation by John C. Dalton.) Vesalius continues in the first edition, "From these pits none which it is permitted to appreciate by the senses penetrates from the right ventricle into the left. So much are we forced to admire the diligence of the creator of all things in a healthy manner by which the blood exudes from the right ventricle into the left through passages which escape vision," and in the second edition he is equally or more positive, thus: "Nor do I find even the minutest channels which would make the septum pervious, although such perforations are described by anatomical professors, who believe implicitly in the passage of blood from the right ventricle into the left. I am therefore in no little doubt as to the function of this part of the heart." (Translation by John C. Dalton.) Vesalius appreciates the fact that blood must go from the right side to the left side of the heart. Galen had appreciated this fact also, and had assumed the existence of the pores in the cardiac septum but Vesalius has no explanation to offer.

The true course of the blood from the right heart to the left heart through the lungs was first described in print by Servetus in 1553, which however did not become generally accessible until 1694 when William Wotton published his *Reflexions upon Ancient and Modern Learning.* Servetus was burned by John Calvin for the religious heresies printed in the same book, and only two complete copies of

the edition survived the same fire. Servetus was a friend of Vesalius, and yet in the second edition of the treatise published only two years after this *auto da fé* Vesalius does not even hint at the pulmonary circulation, and we must suppose that he was ignorant of this discovery of his friend.

At the age of twenty-nine, Vesalius resigned his professorship and studies in science, and took the post of court physician to the Emperor (1544). For twenty years (1544-64), Vesalius apparently gave up all thought of his early work in science, and busied himself with the duties of personal attendance on the Emperor Charles V and his son, Philip II. He lived in the atmosphere of the court as this monarch traveled from Austria and Germany through France, Holland and Italy to Spain.

Vesalius saw the results of the publication of his book written after his long apprenticeship in the dissecting theater. Both applause and condemnation from many contemporaries appeared according as the critics supported the Galenical tradition or the new anatomy of Vesalius. He entered into few controversies with his critics. In the minds of his old teacher, Sylvius, in Paris, and Johannes Dryander in Marburg, Vesalius stood for an insane upstart. By Mathaeus Columbus both in Pisa and in Rome, and later by Bartholomeus Eustachius in Rome, he was criticized as a teacher of error.

The smaller book of Vesalius, known as the Epitome, was reprinted also by Oporinus at Basel in the German language from a translation by D. Albanus zum Thor in the same year, 1543, and issued August 9. This is now equally rare with the latin original, and copies often have lost the frontispiece. It is dedicated to Philip of Spain, and also to Christopher, Duke of Wirtemberg and Teck. A partial reprint of the plates of Calcar called a *Compendiosa totius Anatomie delineatio* was printed in London by John Herford in October, 1545, in which Thomas Geminus has reproduced some of the plates from the Treatise and Epitome by engraving on copper. In these, the drawings of

the muscles are the same but the background different. Geminus republished this book in 1553, and with an English text by Nicholas Udall in 1559, which is shown by Sanford V. Larkey to be derived from Mundinus and Vicary except as to the copper plates. The English text of Geminus has no connection with his own first pirated edition of the "Epitome" of Vesalius. The first edition was dedicated to Henry VIII, and has the royal coat of arms on the title page; the second, to Edward VI, with the same title page; and the third, to Elizabeth. In this edition, the royal effigy replaces the arms of Henry VIII and Edward VI but the portrait resembles that of Mary, the elder sister of Elizabeth, for as Larkey points out, an old note in a Bodleian copy says that Mary died just as the book was being printed and there was no time to change the portrait to correspond with the dedication. No translations of the larger treatise of Vesalius have been published in English.

Vesalius undoubtedly resented the criticism of Columbus more than that of any other contemporary. Mathaeus Realdus Columbus was the prominent and foremost assistant of Vesalius in Padua for six years (1538-44). He carried on the duties of teaching at Padua while Vesalius was absent in Basel at work on the publication of his first edition. Columbus also succeeded to the Patavian professorship when Vesalius left in 1544 to take up the duties of Archiatrus and court physician to Charles V. Vesalius spoke highly in his first edition of his first assistant, Columbus, as "my friend Columbus, skilled professor at Padua, most studious of anatomy," and included a portrait of Columbus as his first assistant in the front rank of the attendants at the portrayal of his public anatomy in the well-known frontispiece of his treatise.

Columbus was born at Cremona in 1494. Like Vesalius, he was the son of an apothecary, and trained in that calling. He did not have as thorough a university education as his contemporary anatomists but he expressed himself clearly, and wrote latin in a finished style. He was twenty years the senior of Vesalius, and subsequent events lead one

to believe that this difference in age created a feeling of envy and secret antagonism against Vesalius as a younger man who was getting more credit than he deserved. As soon as Vesalius left Padua for the imperial service, and Columbus succeeded to the professorship, he showed his true colors, attacked the anatomy of the Vesalian treatise and began to demonstrate in his anatomies examples of anatomical arrangement which resembled those of Galen more than the written word of the Vesalian anatomy of 1543. Any thoughtful student of anatomy today cannot but be impressed with the multiplicity of variation in the structure of the peripheral arteries and veins, of the nerve trunks and of the muscles, in different human cadavers. The very complete *Handbuch der Systematischer Anatomie des Menschen* (1866-71) of Jacob Henle has been looked upon for many years as the last word concerning these anomalies of anatomy. After Columbus transferred to Rome and was joined there by Eustachius, the attacks on Vesalius increased many fold. Columbus with his forced references to Galen, and Eustachius with his more learned comparisons and references to fetal anatomy, aroused Vesalius to bitter counter attacks on these two critics. From his language one might suspect that Vesalius could be a difficult man to please and a hard taskmaster, and that many fancied injuries and insults had rankled in the soul of Columbus. Vesalius hurls at his late assistant such epithets as, "an uneducated being," "a half wit," "a boaster that he had discovered a vein overlooked by me in an unfinished dissection," and similar retributions and angry criticism.

Vesalius found time to leave his court duties for a short period during 1545 and 1549, during which he visited Padua, Pisa, Bologna and Basel, and conducted public anatomies at these universities. Under the influence of personal attacks and disputes, he burned all his manuscript notes and writings in a fit of temper, and followed Charles V to Madrid. It seems probable that Vesalius rewrote his treatise in 1551 while attending on the Emperor at Augsburg. This second edition was printed in large part by 1552,

though dated in 1555, and was published largely as an answer to his detractors. Columbus wrote but one book, which was not published until 1559, just after his own death. This book is palpably modeled after the treatise of Vesalius. It also contains a chapter on vivisection in which Columbus presents no new facts but limits his work to repeating some of the experiments described by Vesalius. Columbus gives the preference to the use of the dog in vivisection as compared with the hog, and for the reason that swine make too much noise under the knife, thus reversing the opinion of Vesalius who preferred the pig because the dog was too quiet. In his book Columbus emphasized that he had discovered the third small ossicle of the ear, and also the pulmonary circulation which he described accurately. Unfortunately for the reputation of Columbus for veracity, the stapes of the ear had been described by both Philippus Ingrassias of Sicily and professor at Naples, and by Bartholomeus Eustachius who relinquished all credit when he heard that Ingrassias had also made the same discovery.

The question of the priority of the discovery of the pulmonary circulation is a much more complicated question to attempt to solve at this date. During the twelve years (1543-55) between the printing dates of the first and second editions of the Vesalian Treatise, this primary discovery of the lesser circulation was published by Servetus (1553). In reading the original texts of Vesalius and his contemporaries, one must remember that all these anatomists, like Vesalius himself, were skillful observers and described, as accurately as their knowledge would allow, the exact findings as they understood them. The science of the sixteenth century dealt with observed facts, and did not trouble itself with inferences from those facts or with theories of any kind, except in studies and publications on theology.

The established theories of the Galenic physiology of the humors taught the differences between the dark-colored nutritional blood of the veins containing "natural spirit," and the lighter-colored spirituous blood of the arteries con-

taining "vital spirit." The blood vessels entering and leaving the heart were classified according to the character of the contained blood with no knowledge of the real direction of the flow of the current in those vessels or of their intimate structure. The pulmonary artery of today containing dark "nutritional blood" was called the arterial or artery-like vein or vena arteriosa, and the pulmonary veins containing bright-colored arterial blood were named venous or vein-like arteries or arteriae venosae. According to the humoral physiology the flow of blood in all arteries and veins alike was thought to be an alternating to-and-fro current from the heart to the lungs or to the periphery of the body, and back again. These observers of the sixteenth century were influenced by this theory of Galen and by the constantly observed to-and-fro flow of air in the windpipe, the arteria aspera of the lungs.

The spirits of the humoral philosophy of life were three —the "animal," the "vital" and the "natural," and life was carried on by the soul acting through these spirits. Much stress was placed upon the location of the soul in the body. Aristotle had placed the seat of the soul in the heart, Galen had transferred its seat to the brain. The materialist philosophers of the sixteenth century who developed the knowledge of the structure of the human body, and led up to the discovery of the circulation of the blood as proved and published by Harvey, located the soul in the blood. The soul of these philosophers was not the immortal spirit of Plato and the theologians but the *anima* of the Roman, the *psyche* of the Greek. This soul carried on life, and manifested intellect, volition, sensation and motion through the animal, or possibly better, cerebral spirit of the brain and nerves; it governed the nutrition, growth and repair of the body through the natural spirit of the venous blood, and it controlled through the vital spirit of the arterial blood the most prominent functions of arteries and all living tissue, viz., their inherent power to pulsate.

This function of pulsation existed in every organ, and was the continuing evidence of the existence of life. The

Galenic theories of life explained this pulsation in the organs of circulation of the blood as a process of suction. The heart was a suction pump, and not a force pump; the swelling of the arteries sucked the blood into them from the heart; the swelling of the pulsating brain sucked air to itself through the cribriform plate of the ethmoid bone, and natural and vital spirits also from the veins and arteries, from which combination the animal spirit was produced by "coction" in the ventricles of the brain. The physiology of the humors laid stress upon the functions of the cavities of organs rather than upon their solid substance. The more or less mystical changes in the blood due to the interchange of oxygen and carbon dioxide gases in the pulmonary parenchyma by which the vital spirit entered the blood, were explained as caused by this specific action known as coction in the left ventricle of the heart. This physiology demanded that all cerebral activity and the formation of animal spirits be a function of the cavities of the brain, and that this animal spirit be transmitted to the skin for sensation, to the muscles for motion by the cavities in the nerves. That these nerves were found to be solid after death did not disturb the acceptance of the theory of the existence of invisible channels in them any more than the absence of demonstrable pores in the septum of the heart destroyed the accepted notion that the blood oozed or filtered through that septum from the right to the left ventricle. Vesalius in his second edition was the first to deny the existence of these septal "foramina" in the heart but he did not follow this discovery to its logical conclusion, and formulate the lesser or pulmonary circulation.

Leonard L. Mackall has reported on the literary remains of Michael Servetus. Servetus was probably born in Tudela in Navarre but his parents lived in Villaneuva de Sigena, Spain. He was a fellow student of Vesalius at Paris under Sylvius and Guinterius, and took his degree of Doctor about 1540, probably at Montpellier. He was more interested in theology even than in medicine. His principal writings were two—the Errors of the Trinity, *De Trinitatis erroribus Libri VII* (1531), and the Re-establishment of Christianity,

Christianismi Restitutio (1553). His heresy was a peculiar unitarianism which was equally abhorrent to Roman Catholicism and to Calvinism. It was Calvin who brought about his execution at the stake in Geneva. Servetus was unquestionably familiar with the anatomical treatise of his fellow student, Vesalius, and he also denied the existence of the septal pores in the heart. Servetus seems to have worked out the fact of the lesser circulation for himself. He introduced into his last book a discussion of the nature of the Holy Ghost which included his accurate description of the pulmonary circulation as a physical explanation of the formation of the "spirits" of the body from which the Holy Ghost is established in the body of man. He wrote:

> There is the vital spirit which is introduced by anastomoses from the arteries into the veins in which it is called natural. First, therefore there is the blood whose origin is in the liver and the veins of the body. Second, there is the vital spirit whose origin is in the heart and the arteries of the body. Third, there is the animal spirit whose origin is in the brain and the nerves of the body. . . . . .
>
> In order that one may understand how the blood is life itself, one must recognize the physical formation of the vital spirit itself, which is compounded and nourished from the inspired air and the most refined blood. . . . . This thin spirit is endowed by the force of heat with a golden yellow color in order that the transparent vapor may be containing in itself, as it were from the more pure blood, the substance of water, of air and of fire. It is formed, as a matter of fact, in the lungs by a mixture of inspired air with the delicately prepared blood which the right ventricle of the heart sends to the left. This communication indeed is made not through the central wall of the heart, as is popularly believed, but the refined blood is driven through a great ingenuity by the right ventricle of the heart in a long route through the lungs. . . . . Thus not simply air but air mixed with blood is sent by the lungs to the heart through the vein-like artery. Therefore this mixture is made in the lungs. The bright color is given to the refined blood in the lungs, not in the heart.

One thousand copies of the first edition of this publication by Servetus were printed for him at Vienne, France. Calvin and the authorities of the Church of Rome tried but failed to destroy the whole edition, and complete copies are now in the State Library at Vienna and the Bibliotéque Nationale in Paris, and an incomplete copy in the University library at Edinburgh. It is known that about 1546 Servetus

sent a copy of this book in manuscript to Calvin at Geneva, and it has been repeatedly thought probable that he also sent a similar copy to his friends in Italy, and that Columbus and others might well have seen or heard of the passage about the circulation. Mackall has examined much of this material, including a manuscript of 1546 of Servetus, but not in his handwriting, which is now in Paris, and which contains the passage relating to the circulation through the lungs. Mackall traces this manuscript back through the La Vallière sale (1784), and the collections of Gaignat, Hoym and Du Fay to a Caelius Horatius Curio, "percelebris bibliopola Basiliensis." The chain is broken at this point, and it seems very uncertain that this bookseller of Basel was any connection of the son of Caelius Secundus Curius, the theologian, who moved to Switzerland from Pavia and Lucca in 1545 because he sought freedom from possible religious persecution in Italy. It must remain an unsolved question but it seems by no means impossible to many that the discovery of Servetus was available to the scientific workers at Padua either before or after 1546 through the aid of the friend of science and of the University, Caelius Secundus Curius, who may have owned this manuscript, or possibly a copy was seen and read by Columbus. I have indicated below a much easier and more plausible manner in which Columbus could have learned of the pulmonary circuit.

Modern writers have been divided in their estimates of Columbus as a reliable observer. John C. Dalton, writing on the doctrines of the circulation in 1884, however, gives him full credit for this discovery of the pulmonary circulation. The exact words of Columbus show that he believed that much of the venous blood going to the lungs was designed solely for the nutrition of the lungs, and that a portion of that blood only was transformed into the highly refined, brilliantly colored blood containing the vital spirit, and returned to the heart.

Sir Michael Foster, however, in his history of physiology published in 1901, gives little credence to the claims of Columbus to priority of discovery of the lesser circulation,

and bases his objections on the proved dishonesty of Columbus. Columbus in his book of 1559 tried to appropriate credit from Ingrassias for the discovery of the third of the aural ossicles (the stapes), and Sir Michael emphasizes that Columbus could easily have seen a copy of the book of Servetus or a manuscript copy at Padua in or about 1546. It cannot be denied that the words of Columbus give the best description of the pulmonary circulation printed before the epoch-making book of Harvey.

Columbus says in his chapter "De corde et arteriis":

Between these ventricles there is a septum through which almost everyone considers that a passage for the blood exists from the right ventricle to the left in order that it may be made more easy for the fine generation of the vital spirit to be restored. But they wander in a long road; for the blood is carried to the lungs by the arterial vein and is refined there; and then together with the air is returned to the left ventricle of the heart by the venous artery.

and later in his chapter "De pulmone," Columbus says:

In truth, these three vessels, arteria aspera, vena arterialis and arteria venalis (trachea, pulmonary artery and pulmonary vein) are embraced by a thin, porous and light substance, and thus the lungs are formed. The function of which is, as the anatomists correctly describe, the cooling of the heart by carrying cold air to it, besides the lung is compelled to act in inspiration and expiration, and so is useful for the voice. And those writers, who antedated me, renewed all these uses of the lungs, in addition to which I add another of the greatest importance concerning which no one has made mention: In fact, this is the preparation and almost the generation of the vital spirit which is later perfected largely in the heart. For this takes the air inspired by the nares and mouth which is carried by means of the arteria aspera (trachea) through the whole lung, in truth the lung mixes this air together with that part of the blood (eo sanguine) which having been perfected is conducted from the right ventricle of the heart by the arterial vein. Indeed, the arterial vein carries what blood is used for its nourishment (of the lung,) and in addition is sufficiently large so that it can supply blood also for this additional function.

The chapter of Columbus "De viva sectione" was translated into English by Louis C. Boislinière, and published in the *St. Louis Medical Review* in October, 1906. One will seek in vain for any description of the pulmonary circulation in this chapter. The above excellent description of the lesser circulation is found in his chapters, "De corde et arteriis"

and "De pulmone." Today one cannot imagine that Columbus could have omitted to describe the pulmonary circulation in his account of his extensive vivisections of the chest and abdomen of the living dog if he had had the slightest notion of the general circulation. A source of this information available to Columbus was nearer to his elbow than any theoretical guess referring to a secret understanding by him of the writings of Servetus. John Calvin was almost successful in blotting out this description from the memory of the general medical profession by his destruction of Servetus and his book.

Columbus had two resourceful students or assistants in his laboratory at Rome: Bartholomeus Eustachius and Andreas Caesalpinus. I must confess that the honesty of Columbus seems to me to be more than questionable. To recapitulate: Columbus is reputed to have stolen credit for the discovery of the stapes from Phillipus Ingrassias, and undoubtedly took credit for the discovery of the pulmonary circulation. Subsequently, the credit for the stapes was returned to Ingrassias by the actual co-discoverer, Eustachius, who had made special studies of the middle ear and whose name is attached to the tube connecting the middle ear with the pharynx. I believe that Columbus stole from both of his assistants: the stapes from Eustachius and the pulmonary circulation from Caesalpinus.

The description of the pulmonary circulation was later printed by Caesalpinus in at least three books: *Quaestionum Peripateticarum, Libri V,* 1571; and 1593, *De Plantis, Libri XVI,* 1583, and *Quaestionum Medicarum Libri II,* 1593. Caesalpinus said in his Peripatetic Questions in 1571 and 1593:

> For that purpose, the lung drinking up the heated blood from the right ventricle of the heart through the artery-like vein and passing on that blood (eam) through anastomoses of the vein-like artery which goes to the left ventricle of the heart; the cold air having been sent meanwhile through the channels of the rough artery (trachea) which proceed next to the vein-like artery, it cools by touch alone, not indeed by communicating openings, as Galen thought. Those things which appear in dissections agree best with this circulation of the blood from the right ventricle of the heart through the

lungs into the left ventricle of the same. For there are two vessels designed for the right ventricle, one admits the same quantity as the other extracts; the membranes (valves) having been made for that purpose. Therefor the vessel emptying into the right is the great vein which is called cava. (*Quaestionum Peripateticarum*, 1593, Liber V, f. 125 verso.)

He repeated his theory of the circulation in the *De Plantis*, 1583, thus:

For in animals we see that nourishment is carried through the veins to the heart as if to the workshop of innate heat which is originated in the heart from the same food and is developed there to its final perfection to be distributed through the whole body in the arteries, by the driving spirit which is formed in the heart from the same food.—(*De Plantis, Liber I*, 1583, p. 3 recto, Cap. II, 11. 2-5.)

In Medical Questions, 1593, Caesalpinus says:

That the openings of the heart are prepared by nature in such a way that an entrance is made from the vena cava into the right ventricle of the heart whence an exit opens into the lungs, that there is besides an entrance from the lungs into the left ventricle of the heart from which finally an exit opens into the aorta artery, certain membranes having been placed in the openings of the vessels that regurgitation may not occur. For thus there is a continuous movement from the vena cava through the heart and lungs into the aortic artery, as we have explained in the peripatetic questions.—(*Quaestionum Medicarum, Liber II*, 1593, f. 234 recto.)

Thus Caesalpinus described on three occasions both the pulmonary and the general circulations as viewed from the flow of blood through the heart on both the right and the left side. But he could not drop the theories of Galen concerning the physiology of life and its pulsations. For him as for all his predecessors and contemporaries the blood flows because the lung drinks it up, or better sucks it up from the right heart, the arteries suck it from the left heart and the left heart sucks it from the lungs, and the right heart sucks it from the venae cavae, superior and inferior (to use modern nomenclature). Caesalpinus first demonstrated by ligatures that the flow of blood in the veins was centripetal, and that in the arteries was centrifugal so far as the heart was concerned.

All these facts must have been known generally in Italy when William Harvey, the Englishman, arrived in Padua

to study under Fabricius in 1599. He remained there three years. After returning to London he became a lecturer and taught the circulation of the blood to his classes during and after 1616 as it is taught today. He did not publish his book, *De motu cordis et sanguinis in animalibus,* until 1628. When criticised by many, by Sylvius in Paris and Riolanus in Amsterdam, on the general demurrer "cui bono? It cannot be right," his general answer was: "I do not know, that remains to be seen." But when one reads today the seventy-two pages of his little book, and one finds vivisection raised to a modern plane of excellence, one must honor an author who knew the value of animal experimentation, and appreciated that he had proved the dual circulation of the blood by that means.

Harvey's great discovery was not so much this double circulation "Motus sanguinis" but its cause "Motus cordis." He likened the action of the heart to a water pump, and thus the heart became a force pump, the arteries, elastic tubes which pulsated under the recurring impulses of the pumping heart.

In the opinion of the writer, the credit for the discovery of the circulation of the blood belongs to William Harvey. The claimants for the honor are many. Caesalpinus is the most prominent and there are others in Italy, in Spain and elsewhere. A recent claimant has been groomed in *"Quellen und Studien zur Geschichte der Natur-Wissenschaften und der Medizin"* (Vol. IV, No. 1), by Max Meyerhof and Tatawi in the person of Ibn an Nafir of Persia, as presenting a theory of the pulmonary circulation in the thirteenth century. Ibn an Nafir was born at Damascus in 1210 A.D. He opposed the anatomy of Galen and Avicenna by denying the passage of blood through the heart septum at the same time affirming the necessity of a flow of blood from the right heart to the left which, entirely on theoretical grounds, he believed must be through the lungs. He described no experiments. As usual Meyerhof and Tatawi suggest that Servetus might have heard in Spain of this Persian. Among these claimants one must remember that the

world knew nothing of Servetus or his discovery until 1694, one hundred and forty-one years after his death, when William Wotton called attention to this theory of the pulmonary circulation in his *Ancient and Modern Learning.* That the claim of Caesalpinus was not known until Bayle presented it in his dictionary in 1695, one hundred and twenty-four years after its publication in the Peripatetic Questions. Harvey has been criticised because he does not mention the source of his first dream on the circulation. The answer is that he mentions in his book; Columbus, Fabricius and Laurentius, a competent, to him recent writer on the history of the circulation (1610). Harvey had no discussion with the dead but devoted all controversy to oppose Joannes Riolanus of Amsterdam, who was the greatest living up-to-date exponent of the Galenic theory of circulation by the pulsation of the organs of circulation during their diastole.

All such questions are answered by Sir William Osler in his monumental catalogue when discussing the question of priority in regard to the introduction of anaesthetics. At no. 1354 Osler quotes Richard Owen and Francis Darwin on priority in scientific discovery.

> He becomes the true discoverer who establishes the truth; and the sign of the truth is the general acceptance. Whoever, therefore, resumes the investigation of neglected or repudiated doctrines elicits its true demonstration and discovers and explains the nature of the errors which have led to its tacit or declared rejection may certainly and confidently await the acknowledgments of his right to its discovery."—Owen (*On the archetype and homologies of the vertebrate skeleton,* London, 1848, p. 76)

> In science, the credit goes to the man who convinces the world, not to the man to whom the idea first occurs.—Francis Darwin: (*Eugenics Review,* 1914.)

Another important discovery was that of the valves in the veins, made but not published by Joannes Baptista Cananus in 1536, but first published by Hieronymus Fabricius ab Aquapendente in 1603. The proof of the existence of these folds was a final convincing evidence of the circulation to one who could understand it but Fabricius explained their use and function as furnishing a check to slow the centrifugal flow of blood in the vein in

order that the blood might be the more equally distributed through the body, and not collect unduly in the lower extremities.

Vesalius and his proof of the impermeability of the cardiac septum, Servetus and his correct description of the pulmonary circulation, Columbus and his "rediscovery" and correct reiteration of the discovery of Servetus, Caesalpinus and his demonstrations of the centrifugal flow in arteries and the centripetal flow in veins and the correct description of the flow of blood through the heart, and Fabricius with his valves in the veins, all failed to formulate the one important fact that the whole blood flowed in two circles, a shorter through the lungs, and a longer through the rest of the body. They failed because they could not see or feel the connecting vessels between the arterial and venous trunks, and would not abandon the humoral physiology and the theory of suction by pulsation of Galen and other predecessors who had assumed the existence of invisible channels between the arteries and veins, but who had viewed this flow of blood as pathological and to be from veins to arteries, and thus to form a prominent cause of disease.

A large part of these investigations were carried on in Padua by the successive incumbents in the chair of anatomy. This succession was as follows: Vesalius, 1537-44; Columbus, 1544-46; Fallopius, 1548-62; Fabricius, 1564-1604, and later the same traditions were continued by Julius Gasserius, 1604-16, and Adrian Spigelius, 1616-25.

These Anatomical demonstrations of Vesalius, or anatomies as they were called, were not held in any large hall or amphitheater with elaborate architectural decoration such as is depicted both in the frontispiece of the de Fabrica by Vesalius and in that of the anatomical books of Columbus. On the contrary, the early lectures of Vesalius were given in a wooden structure built especially for the purpose. The present building of the University at Padua was first used in 1549 while Fallopius was Professor of Anatomy. The illustration of this building shows the interior of the court

Medical Building of the University of Padua.

and a section of the anatomical lecture room in the left part of the upper story of the building. The broadside from which this is taken is printed anonymously, and is dated 1601 at which time Harvey was a student at Padua under Fabricius. The interior is unchanged at the present day. There are no seats, and the audience stood in six rows behind a railing on which books or elbows may be rested—a condition not unknown in the older medical schools of America forty years ago. The guide of the building tells modern visitors of the troubles of the students and professor in securing human bodies for the dissection, and the necessity of keeping a watch for inspecting officers of the law or the church. He points out a small opening from which all visitors may be inspected as they approach, and also the facilities for hiding the cadaver. His enthusiasm leads this guide to affirm that as soon as the anatomical subject had been disposed of by dropping it through a trap, the audience and professor would produce musical instruments, and transform the whole assembly into an orchestra at practice. Such a condition certainly did not exist in the time of Vesalius, and this modern cicerone is more amusing than convincing of the truth of his reminiscent history. It is in the corridors of the court shown in this advertisement of university lectures that the heraldic cartouches of former students, including that of William Harvey, are still to be seen.

Vesalius and his contemporaries had no knowledge of the function of respiration in regard to the absorption of a gas from the air, and of the exchange of oxygen and carbonic acid gas in the lungs. This knowledge was not available until after the death of Harvey (1578-1651), when Boyle had invented the air pump, and experimented with its vacuum, and Mayow (1643-79) had advanced the theory of an absorption by the blood of a nitro-aerial spirit from the inhaled air.

The immediate followers of this Italian school of anatomy of the sixteenth century continued to advance new theories and new observations. Felix Plater in his *De corporis*

humani structura et usu Basel, 1583, formulates the alternating suction action of the heart, of the lungs and of the arteries with the acceptance of the pulmonary circulation. He describes the formation of the spirituous blood in the lung, the suction of the venous blood by the lungs synchronous with the contraction of the heart, and the suction by the heart during chastole of the spirituous blood from the lung into the left ventricle. Caspar Bauhinus of Basel in his *Theatrum Anatomicum,* Frankfort, 1605, repeats the theory of Galen that the blood passes from the right ventricle to the left through the septum of the heart. Gabrielis Fallopius at Padua in his *Institutiones Anatomicae,* Venice, 1584, omits all mention of the pulmonary circulation and continues the theory that the vital spirit is "concocted" in the left ventricle of the heart, that the arterial vein supplies the lungs with a finer quality of blood, and the venous artery carries fuliginous matter from the left ventricle to the lungs and brings back air prepared in the lungs for the cooling of the heart. Fallopius reasserts the complete theory of Galen, and dodges by silence all reference to a pulmonary circulation and to septal pores in the heart. Leonardo Botalli in a special paper (1565) described a series of cases of congenital persistence of the fetal duct now known by his name. This was republished in his *Opera omnia,* 1660. Botalli believed that he had discovered the "lost passage" from the right to the left heart by which the blood found its way from right to left and neither through the arterial vein nor through the cardiac septum. Constantius Varolius in *De resolutione corporis humani, Libri IIII,* Frankfort, 1591, expresses the belief that, following the arrangement of the fetal circulation with its two umbilical arteries and one umbilical vein, the portal vein absorbs the material for the formation of venous blood, and the mesenteric arteries absorb the constituents to produce arterial blood, and transmit the same to the vena cava and the aorta respectively. Thus he eliminates all idea of the passage of blood from the right to the left heart within the chest. Franciscus Ulmus introduced the spleen as the organ intermediate between the veins and arteries, but none of these weird theories

received supporters, and in spite of their important discoveries every one of these brilliant minds of the sixteenth century remained too firm believers in the Galenic theories to be able to grasp the great facts which they all saw but could not explain.

It remained for the Englishman, William Harvey, to complete the proof after his return to England from a course of study of a few years (1599-1602) at Padua under Fabricius.

Between the dates 1562 and 1564, Vesalius undertook his ill-fated journey to Jerusalem. It seems improbable that this was begun to appease the Church and the inquisition of Spain. The report that it was to purge himself of the impiety of having opened a living body to determine the cause of death, has been repudiated as an untrue calumny by the best informed historians of this period (Haeser, Roth and others). Vesalius had been subjected to bitter criticism, engendered largely by jealousy, from the physicians of Spain. He was protected by the influence of Charles V and also, but to a much less degree, by Philip II. In 1556 Charles had referred the whole question of the dissection of the dead to the theological faculty of Salamanca who gave the following decision:

"Since such dissection was indispensable in the opinion of physicians for the increase of knowledge of the healing art, it must therefore be considered as necessary."

It seems more likely that Vesalius became thoroughly disgusted with the treatment of him by the churchmen of his time, and with the priest-ridden government of Philip II, and made the excuse of a pilgrimage to the Holy Land to secure from Philip his discharge and release from his duties as court physician. While in Jerusalem he received word that he had been appointed by the Council of the Venetian Republic to the Professorship at Padua, to succeed Fallopius who had died in 1562. On his return journey his ship was wrecked on the coast of the Island of Xacynthos (Zante), and Vesalius died from the results of the exposure in October, 1564, at the age of fifty.

Vesalius described in his final chapter of the de Fabrica on vivisection the method of tying up an animal for a demonstration in vivisection in a public lecture, and refers to the instruments necessary for such a piece of work. An illustration of these instruments exhibited on a vivisection plank is shown at the end of the first book of the treatise.

Vesalius then closes his de Fabrica treatise (historia) by describing an operation on a living pig which includes all the separate experiments previously detailed. The drawing of the pig tied to the dissection plank is reproduced above, in the latin version of this chapter, and in its translation.

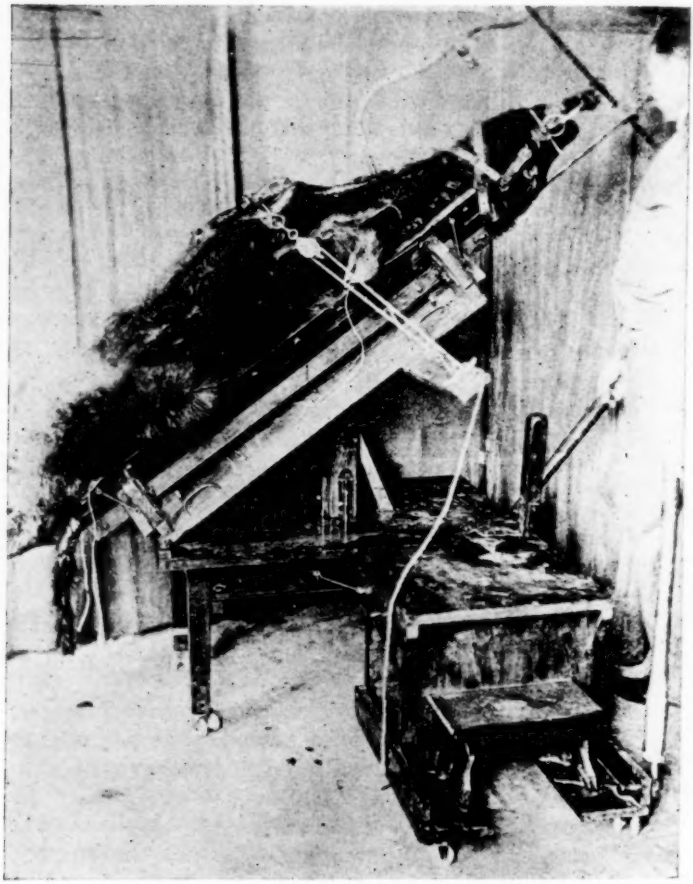
In this vivisection Vesalius proves the function of the recurrent nerves of the larynx which was first discovered by Galen. He then examines the movements of the lung in respiration, and compares the rhythms of the pulsation of the heart, of the aorta, of the pulmonary artery (artery-like vein), and of the pulmonary veins (vein-like artery). In spite of his keen power of observation which had served to break down the application to man of the simian anatomy of Galen, Vesalius misses the true meaning of the heart beat and the arterial pulse, and he reiterates the Galenical functions of the vena cava and other veins as distributors of nutritious blood to the whole body, and gives no hint that he had ever heard of the description of the pulmonary circulation by Servetus.

A similar experimental demonstration was carried out by the late Professor John G. Curtis as a part of his annual course of lectures on physiology at the College of Physicians and Surgeons in the years of his active professorship (1876-1909). There were a number of red-letter events in undergraduate medical education in New York during the closing years of the nineteenth century which attracted students from all the schools of the regular profession in the city. There were four such schools: The College of Physicians and Surgeons at Twenty-third Street and Fourth Avenue; The Womans Medical School of the New York Infirmary at Fifteenth Street and Stuyvesant Square; The New York University and the Bellevue Hospital Medical Schools, both

of which were at the foot of Twenty-sixth Street and the East River. Such outstanding clinics and lectures included the Saturday Surgical Clinics of James Wood at Bellevue; of Thomas M. Markoe, Robert F. Weir and William T. Bull at the New York; and of Henry B. Sands at the Roosevelt Hospital. Students from every school flocked each week and were welcomed to these public clinics which were conducted after the model of the celebrated Hospital Clinics of Paris.

Once a year, "calf day" at 10 a. m. attracted a similar congregation of students of both sexes from all the schools of the city to the old lecture hall of the College of Physicians and Surgeons. At this lecture Professor John G. Curtis would operate on a yearling calf which, after being anaesthetized, was held in a special frame, and kept alive by artificial respiration.

Professor Curtis in accordance with what is and always has been the mental attitude of the doctor of medicine, differed with his contemporary teachers of physiology on a number of particulars in his chosen specialty. His great divergence with his chief, Professor John C. Dalton, was a minor one perhaps but the question whether the heart shortened or lengthened in systole, and its relation to the causation of the apex beat on the skin in the intercostal spaces, did not seem trivial to Professor Curtis. Professor Curtis proved to his own satisfaction at this annual sacrifice of a good red heifer on the altar of science that he was right. His students usually split on this question. Some who feared the coming examination were convinced, and others, being more inquisitive and perhaps more observant, voted mentally that Professor Dalton perhaps was right. And thus both groups of students proved themselves well along in their psychological training for their doctorate, and received in their first year of study an early lesson in the aphorism: Doctors may disagree without stigma on their intelligence or their judgment. During the hour Professor Curtis could show much of the action of the lungs in respiration, and of the general and pulmonary circulation



An anaesthetized calf on a special dissection table.

of which Vesalius and his contemporaries knew so little. Professor Curtis would call attention to the fibrillation of the cardiac muscle, especially of the left ventricle, as a precursor of impending death which Vesalius and his immediate successor, Columbus, had previously called to the attention of their students and audiences. John G. Curtis was a learned and keen student of the classical languages, and wrote most interestingly and scientifically of the discovery of the circulation, and of the philosophical and physiological ideas in the sixteenth and seventeenth centuries of Vesalius, Caesalpinus, Fabricius and Harvey.

One question mentioned by Vesalius which has been left undecided is that of the ethics—of the right and wrong of vivisection. Modern experimentation on animals has developed greatly since the sixteenth century, and the universal use of general anaesthesia results in inflicting on these animals no more suffering than is endured by human beings during surgical treatments; usually, less in fact, for they are not allowed to suffer the pangs of convalescence. Bacteriology and immunology have added to the older methods of vivisection many valuable uses for experimentation on animals both in determining a correct diagnosis of human illness in individual cases, and in the scientific study of the causation of disease, and of its successful treatment by vaccination, inoculation and the administration of antitoxins. The older procedures included demonstrations of the normal physiology of circulation and digestion. This early vivisection included also the training of younger graduates for a career in surgical specialties.

Recent discoveries from experiments on animals include the application of insulin in the control of diabetes, the use of a liver diet in the care of pernicious anaemia, and the perfecting of the transfusion of blood from man to man. The point of attack has changed its character in recent years, and the antiscientists have raised the plea that the dog should be spared because of his friendship for his fellow animal, man, and have concentrated for the present on the saving of dogs from such a fate while leaving the guinea pig,

the rabbit, the white rat and white mouse, the cat, the horse and the monkey to bear the brunt of this sacrifice to the science of immunity as applied to the domesticated animals as well as to man.

Yes, the dog is the friend of man, and the human experimenter is the friend of the dog, and has included rabies and distemper in his curative investigations. There are special reasons why the dog cannot be spared. The dog is omnivorous but largely carnivorous, as is man, and his internal anatomy especially of the liver, gastro-intestinal tract, pancreas and kidneys is akin to that of man. The dog, as no other animal could, has contributed very materially to the control of diabetes and of pernicious anaemia.

The general run of mankind takes but little real interest in dogs and cats, but uses them as puppies and kittens for the amusement of their children, particularly during a summer vacation, and then in its fickleness turns the poor beasts loose in a hard world to make their own living and wander as vagrants through the outskirts of our cities until picked up by benevolent local associations for the prevention of cruelty to animals. In every year in New York, for instance, over 70,000 dogs and cats are rescued from the life of the friendless hobo, and mercifully murdered without giving these animals an opportunity to die as mercifully for the advantage of the rest of their own race, and for the protection from disease of their only natural friends, the race of man.

In April, 1919, Sir William Osler said in opposition to a dog bill before Parliament that he yielded to no one in his love for the dog but that he had a still greater love for his fellow man, and that there should be a monument in every city to the ideal dog for the work which his kind had done in saving life by becoming the subject of experiment (*Brit. Med. Jour.*, 1919, I, 494).

Inscribed to the Animals of the Laboratory of the Medical Sciences:

Salve! et Vale! Thou pitiable dog
Made noble too by thy great gifts to the
Welfare of the world. In the catalogue
Of them which waiting also serve, thou standeth
First, with cavy and calf, with coney and cat,
Awaiting as patiently, the will of man
To live or die, as rodent and ape, that
Man, as fittest, may survive, if you all can
With his help solve the problems of his fate.
Is it martyrdom? Does it seem curious to man
That thou, having no choice, diest gaily,
Accepting premature death,—without hate?
Thou art never more the friend of man
Than when thou diest for him. Ave! et Vale!

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Chic., Professional Press, [1935], 391 p.

MEMBERS ELECTED, MAY 7, 1936

Philip Levine	201 Lyons Avenue, Newark, N. J.
William H. Boone	Roosevelt Hospital
Samuel Feigin	115 East 61 Street
Bernard Glueck	130 East 39 Street
Kenneth M. Metcalf	108 East 79 Street
Samuel Standard	137 East 29 Street

PROCEEDINGS OF ACADEMY MEETINGS

MAY

STATED MEETINGS

May 7

I. EXECUTIVE SESSION—a. Reading of the Minutes; b. Election of Members; c. Presentation of diplomas; d. Report of Nominating Committee.

II. THE ELEVENTH HERMANN MICHAEL BIGGS MEMORIAL LECTURE was delivered by The Rt. Hon. Lord Horder, K.C.V.O., M.D., F.R.C.P., on the subject "Eugenics as a Form of Preventive Medicine."

THE HARVEY SOCIETY (IN AFFILIATION WITH THE NEW YORK ACADEMY OF MEDICINE)

May 21

THE EIGHTH HARVEY LECTURE, "The Physiology of the Bronchial Vascular System," I. deBurgh Daly, Professor of Physiology, University of Edinburgh.

SECTION MEETINGS

COMBINED MEETING OF THE SECTION OF SURGERY and THE NEW YORK DIABETES ASSOCIATION

May 1

I. READING OF THE MINUTES.

II. PRESENTATION OF CASES—a. 1. Resection of carcinoma of the sigmoid colon in a diabetic patient; 2. Diabetic gangrene of the toes treated conservatively, Fred W. Solley.

III. PAPERS OF THE EVENING—a. Mortality in surgical diabetes, F. W. Williams; b. Criteria and technique in surgery of diabetic lower extremities, Thomas J. O'Kane (by invitation); c. The diabetical surgical service, a surgical contribution to the treatment of patients with diabetes mellitus, Beverly C. Smith.

IV. DISCUSSION—Samuel Standard (by invitation); Louis Bowman (by invitation), Arthur Terry.

V. EXECUTIVE SESSION—Section of Surgery. Election of Section Officers and member of Advisory Committee: For Chairman, William F. MacFee; For Secretary, Roderick V. Grace; For member of Advisory Committee, Condict W. Cutler, Jr.

SECTION OF DERMATOLOGY AND SYPHILOLOGY—May 5

I. EXECUTIVE SESSION—a. Reading of the minutes; b. Election of Section Officers and member of Advisory Committee: For Chairman, J. Gardner Hopkins; For Secretary, David Bloom; For member of Advisory Committee, Ray H. Rulison.

II. PRESENTATION OF CASES—Beth Israel Hospital, Good Samaritan Dispensary, Sea View Hospital, Miscellaneous cases.

III. DISCUSSION OF SELECTED CASES.

COMBINED MEETING OF SECTION OF NEUROLOGY AND PSYCHIATRY and THE NEW YORK NEUROLOGICAL SOCIETY—May 12

I. PAPERS OF THE EVENING—a. Spastic pseudosclerosis with a report of its occurrence in three members of the same family, A. M. Rabiner; Discussion: Chas. Davison, Frank Curran (by invitation); b. Radiotherapy in encephalitis lethargica, S. A. Goldberg (by invitation); Discussion: E. D. Friedman, C. W. Schwartz, L. H. Cornwall; c. The value of psychoanalysis as a therapeutic procedure, H. T. Hyman; Discussion: Bernard Sachs, Lawrence S. Kubie, Israel S. Wechsler, Abraham A. Brill; d. Cardiac psychoses and the symptoms of anxiety, Joseph Wortis (by invitation); Discussion: S. Bernard Wortis, Karl M. Bowman (by invitation).

II. EXECUTIVE SESSION—Section of Neurology and Psychiatry. Election of Section Officers and two members of Advisory Committee: For Chairman, Abraham A. Brill; For Secretary, Irving H. Pardee; For two members of Advisory Committee, James H. Huddleson, for four years to fill unexpired term of C. Burns Craig, deceased; Leon H. Cornwall, for five years.

SECTION OF HISTORICAL AND CULTURAL MEDICINE—May 13

I. EXECUTIVE SESSION—a. Reading of the minutes; b. Election of Section Officers and member of the Advisory Committee: For Chairman, Jerome P. Webster; For Secretary, Reginald Burbank; For member of the Advisory Committee, Allen O. Whipple.

II. PAPERS OF THE EVENING—a. Franz Cornelius Donders, Dutch Physiologist and Ophthalmologist, Raymond L. Pfeiffer (by invitation); Discussion: Ralph Lloyd; b. How old the new, James J. Walsh; Discussion: David Riesman (by invitation).

SECTION OF PEDIATRICS—May 14

CASE DEMONSTRATIONS from 7:45 to 8:30

I. EXECUTIVE SESSION—Election of Section Officers and member of Advisory Committee: For Chairman, Alexander T. Martin; For Secretary, Philip M. Stimson; For member of Advisory Committee, Bela Schick.

II. PRESENTATION OF SINGLE CASE REPORTS—a. Babies' Hospital—A case of lymph-epithelioma of the nasopharynx, Alfred G. Langmann, b. Bellevue Hospital—Autovaccination productive of generalized vaccinia in an eczematous infant and the mother, Charles H. Smith, Cordelia K. Dowman (by invitation); c. Bellevue Hospital (Children's Psychiatric Service)—A case of osteopetrositis ("Marble Bones"), Herman Wortis (by invitation); d. Israel Zion Hospital, Brooklyn—A case of prolonged hyperpyrexia, Harry M. Greenwald; e. Jewish Hospital, Brooklyn—A case of bronchogenic carcinoma in a boy of ten years, Abram Kanof (by invitation); f. Lenox Hill Hospital—A case of fatal trichinosis after a clinical course of four days, Irwin P. Sobel; g. Morrisania City Hospital—a case of severe lipemia (with lipemia retinalis) in a child with diabetes mellitus, Daniel J. Dolan (by invitation); h. Mount Sinai Hospital—A case of multiple idiopathic hemorrhagic sarcoma of Kaposi in a five-year-old boy, Bernard S. Denzer; i. New York Hospital—A case of verrucous endocarditis in a child, Edmund N. Joyner, III (by invitation); j. New York Infirmary for Women and Children—A case of an infant with Klippel-Feil syndrome, Clementina J. Paolone, Kate Constable (by invitation); k. Polyclinic Hospital—A case of hysterical paraplegia originated by a chronic sinusitis in an eleven-year-old girl, Benjamin R. Roman (by invitation); l. Post-Graduate Hospital—A case of primary echinococcus cyst of the lungs, Charles J. Leslie (by invitation); m. St. Luke's Hospital—A case of sinus bradycardia, Gertrude H. B. Nicolson (by invitation); n. St. Vincent's Hospital—A case of lipomatosis in insulin injected areas in a boy with diabetes mellitus, George B. Bader (by invitation); o. Willard Parker Hospital—A case demonstrating the Arthus phenomenon, Jerome L. Kohn.

SECTION OF ORTHOPEDIC SURGERY—May 15

I. EXECUTIVE SESSION—a. Reading of the minutes; b. Election of Section Officers and member of Advisory Committee; For Chairman, Nicholas S. Ransohoff; For Secretary, Earl E. Van Derwerker; For member of Advisory Committee, Walker E. Swift.

II. PAPERS OF THE EVENING—a. New type of splint for immobilization of clavicle fractures, Nathan Rachlin (by invitation); b. Operative treatment of clavus, Walter I. Galland; c. A new device for compression fixation of fracture of the neck of the femur, Robert K. Lippman; d. Traumatic coccygodynia, George Duncan (by invitation).

III. GENERAL DISCUSSION.

SECTION OF OPHTHALMOLOGY—May 18

Instructional Hour, 7:00-8:00 p.m.—Some plastic procedures: illustrated by moving pictures, Wendell L. Hughes.

Slit-Lamp—Demonstration of Cases—Milton L. Berliner, Girolamo Bonaccalto, Gordon M. Bruce, Wendell L. Hughes.

Exhibit on Comparative Anatomy of the Eye, 7:30-8:30 p.m.—Edward B. Gresser.

REGULAR PROGRAM

I. EXECUTIVE SESSION—a. Reading of the minutes; b. Reading of resolutions on death of H. H. Tyson, George Huston Bell; c. Election of Officers and member of Advisory Committee: For Chairman, John H. Dunnington; For Secretary, Le Grand H. Hardy; For member of Advisory Committee, Lewis W. Crigler; Demonstration of instrument —An anti-glare frame, Charles Littwin.

II. REPORT OF CASES—a. Bilateral cataracts with acute secondary glaucoma following the use of alpha-dinitrophenol, Olga L. Sitchevska (by invitation); b. Cyclic oculo-motor paralysis, David T. Bishop, Brooklyn (by invitation); c. 1. Complete removal of the lower lid for epithelioma with plastic repair; 2. Partial removal of the lower lid with plastic repair for basal cell carcinoma, Wendell L. Hughes.

III. PAPER OF THE EVENING—Some clinical studies on the ocular signs of intracranial sinus thrombosis, Frank B. Walsh, Baltimore (by invitation); Discussion: Thomas H. Johnson, R. Townley Paton.

SECTION OF MEDICINE—May 19

House Officer and Resident Program

I. EXECUTIVE SESSION—Election of Section Officers and member of Advisory Committee: For Chairman, Clarence E. de La Chapelle; For Secretary, Joseph Hajek; For member of Advisory Committee, Albert R. Lamb.

II. PAPERS OF THE EVENING—a. A case of lead poisoning, Einar Gustafson, Lenox Hill Hospital (by invitation) (15 minutes); Discussion: Armin St. George (5 minutes), Paul Reznikoff; b. Two cases of coronary thrombosis in young men; lead exposure as a possible etiological factor, Brandt F. Steele, Second Medical Division (Cornell), Bellevue Hospital (by invitation) (15 minutes); Discussion: Henry J. Spencer (5 minutes), Paul Reznikoff, Herman O. Mosenthal, Clarence E. de La Chapelle; c. Coarctation of the aorta (adult type): clinical and experimental studies, James Flexner, New York Post-Graduate Medical School and Hospital (by invitation) (15 minutes); Discussion: Herman O. Mosenthal (5 minutes); d. A case of pericarditis with effusion, John L. Caughey, Presbyterian Hospital (by invitation) (15 minutes); Discussion: Dickinson W. Richards, Jr. (by invitation) (5 minutes); e. A case of constrictive pericarditis illustrating Pick's syndrome, Herman Tarnower, First Medical Division, Bellevue Hospital (by invitation) (15 minutes); Discussion: I. Ogden Woodruff (5 minutes); f. Panmyelosis in the course of polycythemia vera, M. F. Steinberg, Mount Sinai Hospital (by invitation) (15 minutes); Discussion: D. S. Oppenheimer (5 minutes), N. Rosenthal; g. A case of scurvy in an adult, with studies on the ascorbic acid content of urine, Abraham G. Cohen, Beth Israel Hospital (by invitation) (15 minutes); Discussion: I. W. Held (5 minutes).

SECTION OF OTOLARYNGOLOGY—May 20

I. EXECUTIVE SESSION—a. Reading of the minutes; b. Election of Section Officers and member of Advisory Committee: For Chairman, Edmund Prince Fowler; For Secretary, Charles W. Depping; For member of Advisory Committee, Westley M. Hunt.

II. PRESENTATION OF MEMORIAL FOR ARTHUR B. DUEL—By John B. Rae (by invitation).

III. PRESENTATION OF CASES—a. Interesting cases of lateral sinus thrombosis, Henry M. Scheer; b. Inter-lobar abscess probed and drained through the cribiform plate, J. Ivimey Dowling.

IV. PAPERS OF THE EVENING—a. Milk injections for pharyngeal and laryngeal infections, Ward C. Denison; b. Foreign bodies in the pharyngeal wall with special reference to localization, Isaac M. Heller; Discussion: Ramsay Spillman; c. 20 years' experience with iodine powder (Sultzberger) in the conservative treatment of oral and nasal suppuration, M. D. Lederman; Discussion: H. M. Scheer, M. J. Mandelbaum; d. Recent advances in the hearing sensation, John Guttman.

SECTION OF OBSTETRICS AND GYNECOLOGY—May 26

I. EXECUTIVE SESSION—Election of Section Officers and member of Advisory Committee: For Chairman, Arthur M. Reich; For Secretary, Thomas E. Lavell; For member of Advisory Committee, Francis W. Sovak.

II. REPORT OF CASE—Ruptured uterus—peritonitis and recovery, Ralph L. Barrett.

III. PAPERS OF THE EVENING—a. Spontaneous rupture of the pregnant uterus, Abbey D. Seley, Brooklyn (by invitation); Discussion opened by Ralph A. Hurd; b. The treatment of placenta previa, Locke L. Mackenzie; Discussion opened by Hervey C. Williamson; c. Some aspects of ovulation and menstruation as revealed by nine hundred endometrial biopsies, John Rock, Boston, Assistant in Gynecology, Harvard Medical School (by invitation); Discussion opened by Raphael Kurzrok, Samuel A. Wolfe, Brooklyn (by invitation).

IV. GENERAL DISCUSSION.

SECTION OF GENITO-URINARY SURGERY

The following were elected at the April meeting of the Section: Chairman, Roy B. Henline; Secretary, Fedor L. Senger; Member of Advisory Committee, Augustus Harris.

There was no May meeting of this Section.

AFFILIATED SOCIETIES

NEW YORK ROENTGEN SOCIETY *in affiliation with* THE NEW YORK ACADEMY OF MEDICINE

May 18

I. PAPER OF THE EVENING—Accessibility of tumors to radiation therapy with respect to their derivation, Charles F. Geschickter, Baltimore (by invitation).

II. DISCUSSION—To be opened by Francis Carter Wood (by invitation), William Harris, Ira Kaplan, Maurice Lenz.

III. EXECUTIVE SESSION.

NEW YORK MEETING OF THE SOCIETY FOR EXPERIMENTAL BIOLOGY AND MEDICINE AT THE NEW YORK ACADEMY OF MEDICINE—May 20

I. Blood amylase response to acetyl-betamethylcholine chloride in rabbits, A. Schifrin; L. Tuchman, W. Antopol (Introduced by H. Sobotka).

II. Arrest of convulsions of experimental origin by acetylcholine, in the cat, H. C. Coombs, O. M. Cope.

III. Effect of tannic acid on intranasal infection with pneumococci, H. R. Cox, G. Rake.

IV. Concentration and purification of gonadotropic substance in urine of ovariectomized and post-menopausal women, L. Levin, H. H. Tyndale (Introduced by P. E. Smith).

V. "Fat-metabolism" hormone and hyperglycemia, B. Harrow, A. Mazur, I. M. Chamelin, A. Lesuk.

VI. Inhibitory effect by hypophysis of rats following injections of pregnant mare serum hormone, C. Hamburger (Introduced by E. T. Engle).

VII. A new rapid method for direct typing of pneumococcus in sputum of pneumonia cases, S. J. Klein, G. Heller (Introduced by F. P. Gay).

VIII. Some properties of Castle's intrinsic factor, C. Flood, R. West.

NEW YORK PATHOLOGICAL SOCIETY *in affiliation with* THE NEW YORK ACADEMY OF MEDICINE

May 28

I. CASE REPORTS—a. Hodgkin's disease involving the stomach with fatal hemorrhage, Julius Redish (by invitation); b. Histology of homoplastic suprarenal transplant surviving for eight months in a case of Addison's disease, Frederick A. Hemsath (by invitation).

II. PAPERS OF THE EVENING—a. Hereditary early death in localized neurones with resulting paralysis in dogs, Charles R. Stockard (by invitation); b. Hemorrhagic extravasations into valvular leaflets and their relationship to pulmonary embolism, Eugene Clark, Adolph Berger (by invitation).

III. EXECUTIVE SESSION.

DEATH OF FELLOW OF THE ACADEMY

RANDOLPH, JOHN MONTGOMERY, M.D., 131 Main Street, Rahway, New Jersey; graduated in medicine from New York University College of Medicine in 1888; elected a Fellow of the Academy March 4, 1909; died May 17, 1936. Dr. Randolph was attending surgeon to the Rahway Memorial Hospital for many years and was for forty years physician for the Pennsylvania Railroad.

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1936

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* Deceased